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The Engineer

VOL. 198—JULY TO DECEMBER, 1954

LONDON:
28, ESSEX STREET, STRAND, W.C.2

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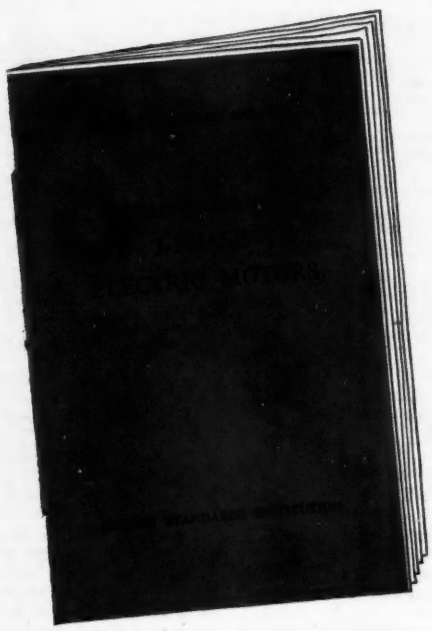

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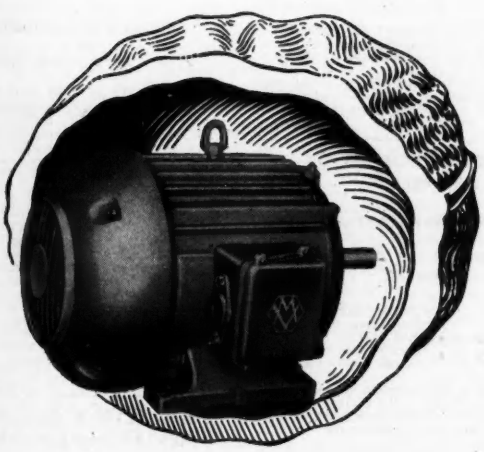

METROPOLITAN-VICKERS
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J/A401

THE ENGINEER

ESTABLISHED 1856

Vol. 198 No. 5136

JULY 2, 1954

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NOTICE TO READERS

All letters intended for insertion in 'The Engineer' or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications. No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.

SUBSCRIPTIONS

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WORDING OF ADVERTISEMENTS: Approximately the first 25 letters of each advertisement are set in heavy type. Advertisers are therefore advised to begin their advertisements with the words they want emphasized.

Advertisements received by Mid-day Tuesday will appear in the issue of Friday the same week. Orders must be accompanied by a remittance.

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PUBLIC APPOINTMENTS

UNIVERSITY OF CAPE TOWN

APPOINTMENTS

Applications are invited for the following posts, viz.:—

(a) CHAIR of MECHANICAL ENGINEERING.
(b) SENIOR LECTURESHIP.

Mechanical Engineering: take charge of engineering geometry, machine drawing and design, and give lectures in mechanical engineering.

(c) LECTURESHIPS.

Civil Engineering: practical experience or research work in design and construction of works will be a recommendation.

Mechanical Engineering: mainly to teach drawing and design and general engineering.

The substantive salary scales are:—Professor, £1600–£100–£1950 per annum (the scale recognised for the Provident Fund is £1400–£50–£1600). Senior Lectureships: £1200–£50–£1450 per annum (the scale recognised for the Provident Fund is £1050–£1400 per annum. Lectureships: £850–£50–£1150 per annum (the scale recognised for the Provident Fund is £800–£1050 per annum). There is also a temporary cost-of-living allowance for a married man (at present £234 per annum).

Applications (with copies of testimonials) should state age, experience, qualifications, and research work completed or in progress, and give the names of two referees whom the University may consult. Two copies of the application and testimonials should reach the Secretary, Association of Universities of the British Commonwealth, 5, Gordon Square, London, W.C.1 (from whom a memorandum giving the general conditions of appointment should be obtained), not later than 31st August, 1954. An additional copy should be sent direct by air mail to the Registrar, University of Cape Town, Private Bag, Rondebosch, Cape Town, South Africa, by the same date.

The University reserves the right to appoint a person other than one of the applicants or to make no appointment. E9341

UNIVERSITY OF DURHAM

KING'S COLLEGE, NEWCASTLE UPON TYNE

DEPARTMENT OF CIVIL ENGINEERING

The Council of King's College invite applications for a LECTURESHIP in CIVIL ENGINEERING.

The salary scale rises by annual increments of £50 to a maximum of £1100. The commencing salary of the successful applicant will be fixed at a point on that scale in accordance with his qualifications and experience and will not, in any case, be less than £500. Family allowance and F.S.S.U. Duties to commence on 1st October, 1954.

Applicants should have had experience in hydraulics and public health engineering (water supply, sewage treatment, &c.), and be able to lecture and organise laboratory and research courses on these subjects.

Twelve copies of application, together with the names of three persons to whom reference may be made, should be submitted not later than 31st July, 1954, to the undersigned, from whom further particulars may be obtained.

G. R. HANSON,
E9394 Registrar of King's College.

MANCHESTER MUNICIPAL COLLEGE OF TECHNOLOGY

(FACULTY OF TECHNOLOGY IN THE UNIVERSITY OF MANCHESTER)

APPOINTMENT OF ASSISTANT LECTURER IN MECHANICAL ENGINEERING

The Governing Body invites applications for an ASSISTANT LECTURESHIP in MECHANICAL ENGINEERING in the College of Technology, with the title and status of Assistant Lecturer in the University of Manchester.

The Department covers a very wide range of aspects of mechanical and production engineering and all members of the staff are expected to undertake, assist in or supervise research.

Salary: £500 per annum, rising by annual increments of £25 to £600 per annum.

Conditions of appointment and form of application may be obtained from the Registrar, College of Technology, Manchester, 1. The last day for the receipt of applications is 21st July, 1954.

Canvassing, either directly or indirectly, will disqualify a candidate for appointment.

B. V. BOWDEN,
E9410 Principal of the College.

NORTHAMPTON POLYTECHNIC, LONDON, E.C.1.

INSTRUMENT DEPARTMENT

LECTURER

Applications are invited for vacancy on full-time LECTURING STAFF of Instrument Department, commencing 1st September, 1954.

Candidates should have wide instrument making experience, a knowledge of aircraft or industrial instruments and preferably H.N.C. or equivalent qualification.

Salary in accordance with London Technical Burnham Scale, Grade A, viz., £415 by £18 to £670 with allowance of £60 for graduates or equivalent and up to £54 for training, plus London allowance of £36 (£48 if over 37).

Particulars and form of application from Secretary.

J. E. RICHARDSON, Ph.D., B.Eng., M.I.E.E.,
E9439 Principal.

PUBLIC APPOINTMENTS

WEST RIDING COUNTY COUNCIL

CASTLEFORD, WHITWOOD MINING AND TECHNICAL COLLEGE

ASSISTANT GRADE B

Required for September, 1954, or as soon thereafter as possible:—

Engineering Department: ASSISTANT, Grade B, to teach Heat Engines and other subjects to Higher National Certificate standard. Applicants should possess suitable qualifications and have had industrial experience and teaching experience in National Certificate Courses.

Salary in accordance with the appropriate Burnham Technical Scale.

Application forms obtainable from the undermentioned should be returned within fourteen days of the appearance of this advertisement to M. G. Swaine, 2, Wesley Street, Castleford. E9350

ESSEX

SOUTH-WEST ESSEX TECHNICAL COLLEGE

Forest Road, Walthamstow, E.17

LECTURER

Required, as soon as possible, LECTURER to teach Mechanics of Fluids, Theory of Structures and Applied Mechanics to Higher National Certificate standard. Salary, £940 by £25 to £1040 per annum, plus London Allowance. Applications (no forms), stating age, training, qualifications and experience, to the Clerk to the Governors. E9413

CITY OF PORT ELIZABETH

CITY AND WATER ENGINEER'S DEPARTMENT

(A) QUANTITY SURVEYOR, (B) SECOND GRADE ENGINEERING ASSISTANT

Vacancies: (a) QUANTITY SURVEYOR, (b) SECOND GRADE ENGINEERING ASSISTANT.

Applications are invited for the above-mentioned positions in the City and Water Engineer's Department, Municipality of Port Elizabeth, in Grade 4 (£735 by £48 to £975) and Grade 7 (£540 by £32 to £700), respectively.

Cost-of-living allowances on the following basis are at present payable:—

Married persons, £540–£600, £264 per annum; £601 upwards, £288 per annum. Single persons, £176 16s. per annum.

In the case of (a) the successful applicant is required to be a Member of the Chapter of Quantity Surveyors or an equivalent thereto and he will be responsible for the preparation of bills of quantities, measured statements and finalisation documents connected with the Council's housing scheme, architectural projects, &c.

In the case of (b) the successful candidate should have passed Sections A and B of the examinations of the Institution of Civil Engineers or hold a University Degree.

Applications to be submitted on or before Saturday, the 31st July, 1954, to Davis and Soper, Ltd., 52 and 54, St. Mary Axe, London, E.C.3.

22nd June, 1954. E9365

BRITISH ELECTRICITY AUTHORITY

LONDON DIVISION

CIVIL ENGINEERS

CIVIL ENGINEERS (3rd Assistant) (Vac. No. 506), required for work on design and construction of power stations. Applicants should be suitably qualified, with some years' experience of power station construction and administration of contracts. A knowledge of the design of steel and reinforced concrete structures and general civil engineering works is essential, and the practical application of soil mechanics principles would be an advantage. Salary in accordance with N.J.B. Agreement, Schedule C, Class AX/EX, Grade 4, within range £801 3s./£1053, and Grade 5, within range £681/£927 3s. p.a., inclusive of London Allowance.

CIVIL ENGINEERS (Juniors) (Vac. No. 507), required for training in general civil engineering work connected with the construction and maintenance of power stations. Applicants must have Higher National Certificate in Civil and/or Structural Engineering and have good knowledge of theory of structures and applied mechanics. Salary in accordance with N.J.B. Agreement, Schedule C, Class AX/EX, Grade 9, within range £415/£618 9s., inclusive of London Allowance.

Applications, quoting Vac. No. for the above vacancies, may be made on forms obtainable from Divisional Secretary, British Electricity Authority, London Division, Generation House, Gt. Portland Street, W.1, closing date 19th July, 1954. E9420

MINISTRY OF WORKS

SOUTHERN ENGLAND

ASSISTANT CIVIL ENGINEERS

Ministry of Works has vacancies for ASSISTANT CIVIL ENGINEERS for work on sites in Southern England. Candidates must be of British birth, have passed or gained recognised exemption from Sections A and B of the A.M.I.C.E. examination and have had experience of site construction work. Although unestablished, these posts have long-term possibilities and competitions are held to fill established posts. Hostel accommodation is available on sites. Salary range £638 to £988 per annum; starting pay up to £885 per annum according to age and experience.—Application forms, quoting E280/54/A, from M.L.N.S., Technical and Scientific Register (K), 26, King Street, S.W.1. E8931

PUBLIC APPOINTMENTS

THE ELECTRICITY BOARD

BELIZE, BRITISH HONDURAS

ELECTRICAL ENGINEER

Applications are invited for the appointment of an ELECTRICAL ENGINEER in the service of the Electricity Board, Belize, British Honduras.

The present supply system, which is 110/220 volt, three wire D.C., is to be changed over to 6600 volts and 220 volts, three-phase, 60 cycles A.C.; three new 800kW diesel-alternator sets are to be installed and two existing 400kW diesel sets converted from D.C. to A.C.

The engineer will be required, initially, to supervise the change over of the distribution system from D.C. to A.C. and the erection of the generating sets and ultimately to take charge of the operation and maintenance of the distribution system and the generating plant.

Candidates should be Corporate Members of the Institution of Electrical Engineers or hold qualifications exempting them from the Institution examination and must have had considerable experience in the construction and operation of L.V. overhead distribution networks and H.T. overhead lines up to 6600 volts. They must also have had some experience in the erection and operation of diesel engines up to 1000 H.P.

The appointment will be on a salary scale of £900 per annum, rising by annual increments of £150 to a maximum of £1200 per annum. The point of entry into the salary scale will depend on the candidate's age, qualifications and experience. Details of Provident Fund, 6 per cent.

A car allowance of £5 per month will be paid.

The appointment will be for a period of three years in the first instance, terminable by three months' notice on either side and may be renewable by mutual consent.

Free passages will be provided for the officer and his family up to four full passages, on first appointment, on termination of the agreement and for long leave in the United Kingdom.

Leave is earned at the rate of sixty days per year of residence in service and may be accumulated. (Earned leave to the United Kingdom may be taken after three years' service.)

Applications, endorsed "Electrical Engineer, Belize," stating age, qualifications and experience, should be forwarded within 21 days of the date of this advertisement to the undersigned, who will communicate with candidates selected for further consideration.

PREECE, CARDEW, & RIDER.
8–12, Queen Anne's Gate,
Westminster, S.W.1. E9456

DEPARTMENT OF ATOMIC ENERGY

ATOMIC WEAPONS RESEARCH ESTABLISHMENT, ALDERMASTON, BERKS

VACANCIES FOR LEADING DRAUGHTSMEN AND DRAUGHTSMEN

Vacancies for LEADING DRAUGHTSMEN and DRAUGHTSMEN at the Atomic Weapons Research Establishment, Aldermaston, Berks, for drawing and design work on all branches of engineering.

LEADING DRAUGHTSMEN (Ref. 172/W.G.E./25). Applicants should have had at least three years' workshop experience, together with extensive drawing-office experience. They should possess the Higher National Certificate or equivalent. Range of pay £635, rising to £742 per annum.

DRAUGHTSMEN (Ref. 173/W.G.E./25). Applicants should have had at least three years' workshop experience, together with some drawing-office experience. They should possess the Ordinary National Certificate. Consideration will be given to applicants who have completed S.2 of the O.N.C. or who have had no drawing-office experience, always providing they have had at least three years' workshop experience. Range of pay £400, rising to £640 per annum.

General information: Starting pay for both grades will depend on age, qualifications and experience.

Houses will be available within a reasonable period of time for selected applicants if married and living outside the radius of the Establishment's transport facilities.

Full details on application to the Administrative Officer (Recruitment), A.W.R.E., Aldermaston, Berks, quoting the appropriate reference number. E9344

COUNTY BOROUGH OF BARNSLEY

WATERWORKS DEPARTMENT

APPOINTMENT OF ASSISTANT ENGINEER

Applications are invited from Chartered CIVIL ENGINEERS for appointment as ASSISTANT ENGINEER in an established post in the Waterworks Department, at a salary in accordance with Grades VI/VII of the National Scales for Local Authorities' Staffs.

The appointment will be subject to (a) the Scheme of Conditions of Service for A.P.T.C. Staff; (b) any other general conditions of employment in operation within the Corporation from time to time; and (c) one month's notice on either side.

The appointment will also be subject to the Local Government Superannuation Acts, for which purpose the successful candidate will be required to pass a medical examination.

Forms for the guidance of applicants should be obtained from the Waterworks Engineer and Manager, Waterworks Office, Town Hall, Barnsley, Yorkshire, by whom applications should be received not later than the 31st July, 1954.

Canvassing will disqualify.

A. E. GILFILLAN,
Town Clerk.

Town Hall,
Barnsley,
24th June, 1954. E9426

PUBLIC APPOINTMENTS

ATOMIC WEAPONS RESEARCH ESTABLISHM
ALDERMASTON, BERK

SCIENTIFIC OFFICERS

The Atomic Weapons Research Es
Aldermaston, Berks, requires S
OFFICERS for the following posts:—

Post 1.—(Ref. 109/WGE./25), PHYSIC
NEER, to undertake studies on the
effects of stresses applied to atomic
Research experience in the field of n
general physics, although not essentia
advantageous.

Post 2.—(Ref. 161/WGE./25) PHYS
work in close conjunction with a group
engaged in research on radio-active m
sound practical and theoretical knowle
tronic counting techniques is essential;
in the detection and measurement
radiations is desirable.

Post 3.—(Ref. 400/WGE./25), PHYSI
work of a qualitative and quantitative sp
analysis of inorganic substances. Ex
spectroscopic research work or metallurg
would be an advantage.

Applicants should have a First or S
Honours Degree in Physics or equivale
tions, for Post 1 qualifications in mec
neering would be acceptable. Start
dependent on post-graduate experience, a
tions, &c., and assessed within the
£815 p.a. The rates for women are
Houses available within a reasonable
married staff who live outside the Es
transport facilities.—Application form f
Officer (Recruitment), A.W.R.E., A
Berks. Quote appropriate reference n

HER MAJESTY'S COLON SERVICE

NIGERIAN RAILWAY

DIESEL ELECTRIC SUPERINTE

Duties include the supervision of oper
and servicing of diesel-electric locomo
jurisdiction of the District Superintende
ment is pensionable on agreement in the
at fixed salary of £1435 p.a. or on cont
salary of £1725 p.a., with a gratuity o
payable on satisfactory completion of co
expatriation allowance of £300 or £350
payable in either case.

Free first-class passages are provided
way each tour for an officer and his w
allowance up to £75 each per year is
respect of a maximum of two children.
quarters, if available, are provided at a re
of 10 per cent. of basic salary and leave
at the rate of one week for each month
service after a tour of 18 to 24 months.

Candidates between the ages of 30–45
have passed or be exempt from Parts A
examination for either A.M.I.E.E. or A.
They should have served an apprenticesh
nised training course with a company
diesel-electric locomotives or have had
experience with such a company. Similar
with a first-class railway would be acce
must have had extensive experience i
maintenance and repair of diesel engine
equipment and mechanical parts of d
locomotives and have some railway oper
rience. Knowledge of machine and
methods is necessary.

Apply in writing to the Director of R
Colonial Office, Great Smith Street, Lond
giving briefly age, qualifications and
Mention reference number BCD.110/

THE BRITISH IRON AND S RESEARCH ASSOCIATI

SWANSEA LABORATORIE

APPOINTMENTS

The British Iron and Steel Research A
require at their Swansea Laboratories:

(A) A GRADUATE METALLUR
PHYSICIST with metallurgical experienc
on the development of new processes for
continuous coating of steel strip with
materials. Experience in the use of X-ray
diffraction apparatus would be an advan
work is of wide interest, involving problem
lurgy, physics of surfaces, and steel str
plant. (B) A GRADUATE PHYSICIST
TRICAL ENGINEER, to work on the de
of new techniques of measurement and
coating processes and product inspection.
of instrument research and development
electronic techniques is desirable. The l
are situated adjacent to Swansea Univers
in Singleton Park. Commencing salary
positions up to £740 p.a., according to ag
rience. Post is superannuated under the
Written applications only, quoting "Sw
Personnel Officer, B.I.S.R.A., 11, Park Lan
W.1.

PRODUCTION ENGINEER RESEARCH ASSOCIATI

RESEARCH ENGINEERS

Production Engineering Research A
vacancies for RESEARCH ENGINEERS.
tions are invited from Engineers to
research on machine tools, machining
pressworking of metals and allied subject
dates should have a First or Second-Class
Degree. For men with initiative there
opportunities for advancement. Super
under F.S.S.U. Full details, including a
ence, qualifications and salary required to
P.E.R.A., Melton Mowbray, quoting R.19

THE ENGINEER

JULY 2, 1954

British Exhibition at Copenhagen

SIR NORMAN KIPPING, director-general of the Federation of British Industries, has announced this week that a British trade fair is to be held at Copenhagen from September 29 to October 16, 1955. This exhibition will have the full support of the British and Danish governments, and, like the British exhibitions in 1932 and 1948, is to be organised by the British Import Union of Denmark in collaboration with the Federation of British Industries. It is confidently believed that in a period of growing competition, the trade fair and exhibition will provide a timely opportunity for British manufacturers to show Denmark and neighbouring countries the latest developments in both capital and consumer goods, ranging from heavy engineering and transport to textiles, leatherware and pottery. The exhibition will be held in Copenhagen's Tivoli Gardens and in the Forum, where the existing buildings will be supplemented by British-made temporary structures. Mr. John Lansdell has been appointed co-ordinating designer, assisted by two Danish architects, Mr. Simon Henningsen (for the Tivoli Gardens) and Mr. O. Gundlach-Pedersen (for the Forum). In addition to the trade exhibits, plans are being made for spectacular British attractions to be staged in Copenhagen during the period of the exhibition. The Federation of British Industries is making available the services of its subsidiary company, British Overseas Fairs, Ltd., which was formed last year to run the British Trade Fair at Baghdad. Mr. D. A. Lamb, the company's Exhibition Organiser, will be manager of the Copenhagen Trade Fair and Exhibition, with a Danish assistant, and the company will be responsible for all arrangements in the United Kingdom. As far as possible space charges will be on the same basis as in 1948, taking into account the increases in costs since then. A prospectus will be issued early in September, but meanwhile inquiries from prospective exhibitors will be welcomed by British Overseas Fairs, Ltd., 21, Tothill Street, London, S.W.1.

Geological Survey

THE importance to the engineering and mining industries of the work done by the Geological Survey is well brought out by the report, for the year 1953, of the Geological Survey Board and the Director of the Survey, which has just been published by Her Majesty's Stationery Office. During that year the Geological Survey carried out a great deal of consultative and advisory work on problems of exploration, planning and production in the coalfields, on the investigation of other mineral deposits, on resources of underground water supply and on civil engineering problems. This consultative work occupied a large proportion of the time of the staff. In its basic task of preparing primary geological maps of Great Britain on the 6in scale, the Survey completed 295 square miles of ground, compared with 200 in 1952. The many topics mentioned in the report include a drilling campaign in the Bristol-Somerset coalfield; a report on the relation between coal seams in the Neath and Dulais valleys of South Wales, in connection with plans for a new colliery; long-term plans for the development of the Midland iron ores; mapping in the Cheshire salt basin; prospects of renewed lead and zinc mining in Derbyshire; and Scottish hydro-electric schemes. The Survey obtains a great deal of information concerning the nature and arrangement of rocks deep below the surface by interpreting their distribution at the surface, and from existing mines and borings. To supplement this information, the Survey is employing geophysical methods—instrumental measurement of small variations in gravity, of the magnetic and electrical properties of rocks beneath the surface, and of the rate at which the rocks transmit tremors from explosive charges. In 1953, the Survey also carried out special deep boring at Ashton Park, Bristol; Upton, near Burford Canvey; Island, and Cambridge, as part of an investigation of the structure of southern England deep beneath its thick blanket of relatively new rocks. The recent publicity given to the possibilities of commercial atomic power had increased the interest shown in prospecting for radio-active materials in many parts of the world. The Atomic Energy Division of the Survey carried out, in addition to fundamental research on radio-active elements and the production of reports on submitted samples, a substantial amount of radiometric prospecting. The uranium resources discovered in this country, mainly in Devon and Cornwall are, as yet, insufficient to justify the construction of a plant to treat the ore. Such a plant would cost about a quarter of a million pounds to construct. Efforts are therefore being made to discover further sources. In the Colonies surveys have been made in the Rhodesias, Nyasaland and Jamaica. A vehicle fitted with portable equipment covered some 8000 miles of bush track and open veldt in Bechuanaland and Swaziland during a radiometric survey. In addition to its other work on the seeking of radioactive materials, the Survey has developed a sensitive lightweight Geiger counter, which is being produced for sale to prospectors and mining companies.

Standardisation of Pallets

THERE was much trade and general interest manifest in the recent meeting of the Pallets Committee of the International Organisation for Standardisation, which was held at the British Standards Institution's headquarters in London last week. It was attended by forty-four delegates from many parts of the world and at the meeting of the main committee, six resolutions concerning the dimensions and loading of standard pallets were agreed. It was decided that the maximum height from the ground to the underside of the top deck should be 5in, the minimum height for the passage of forks from any side should be 3¼in and the width of wing pallets should be 3½in. Maximum tolerances to be allowed on the length and width of standard pallets were specified. The minimum rating for pallets of 32in by 40in and 40in by 48in should be 1000kg and the minimum stacking load 4000kg, the question of test loads being deferred. A third I.S.O. standard size of pallet of 32in by 40in was recommended for final approval. The Group's next meeting, which is to be held in a few months' time in Amsterdam, will be concerned mainly with matters affecting the handling of pallets at ports, with particular reference to a proposed international stevedores pallet. Requests were made that expendable pallets, chamfering of pallets, and the minimum percentage area of bottom decks of pallets should be added to the agenda and it was also agreed that in future discussions of pallets consideration should be given to their use by all forms of transport, whether by sea, river, road, rail or air.

Forest Products Research in 1953

THE D.S.I.R.'s annual report for 1953 on forest products research points out that the major project receiving the attention of the Forest Products Research Laboratory at Princes Risborough was, as in previous years, the testing and evaluating of new tropical timbers likely to be of importance to manufacturers and timber users. Another important function of the Laboratory was the satisfying of the increasing demand from the timber industry for data and advice on day to day problems. These two major charges on the resources of the Laboratory resulted in some slowing up of the long-term research. Nevertheless, several advances are recorded in the report. A development in kilning technique was the use of superheated steam as a drying agent. Although this method has previously been used, chiefly in the drying of softwoods, knowledge of its use in the kilning of hardwoods is scanty. Tests on two lightweight hardwoods showed that they can be dried in about a third of the time taken by traditional treatment. The amount of checking and distortion is only slightly greater than that resulting from normal kiln drying but collapse occurs to an appreciably greater extent. The new process developed at the Laboratory for making plywood corners of small radius has been of considerable interest to the furniture and other woodworking industries and a successful innovation has been the use of low-voltage metal-heating elements of large area for applying heat to the glue lines. The technique employed in making laminated bends of large section in boat building is being investigated. The use of high softening temperatures in the bending of English oak has also been the subject of experiments. Weathering tests of plywood have been carried out, both in this country and in Nigeria, over a period of three years, the principal object of the tests being to assess the durability of the glues. Resins of the phenol and resorcinal types showed negligible deterioration but others tended to fail in the most severe tropical exposures.

Motorways in Texas

ON Thursday, June 24th, Mr. D. C. Greer, Texas State Highway Engineer, presented a paper before the Institution of Highway Engineers entitled "Texas Expressways." Mr. Greer pointed out that the greatest difficulty in providing "expressways" (i.e. divided highways with at least four through lanes for express traffic, outer frontage roads, and control of traffic access) had been lack of adequate funds and lack of understanding by the public of this new system of highway use as it related to the abutting land. The aim was, he noted, to provide a safer highway, a more efficient highway whose capacity was not reduced by marginal interference, and a highway which would not impair the use and value of abutting land. It had been possible to reduce accidents by at least 75 per cent when an expressway was substituted for an ordinary highway and it was conservatively estimated that such substitution gave a saving of 2 cents per mile for cars. The expressway required a right of way 300ft wide, Mr. Greer continued, and cost five to ten times as much as an ordinary highway. All such roads in Texas had to earn their construction and maintenance costs from road user taxes, and generally a predicted traffic volume of 20,000 vehicles per day within twenty years would justify expressway development. Lesser volumes would warrant such construction if the proportion of trucks or of through traffic was high. Actual wheel loads had stabilised in Texas, he said, at a general maximum of about 13,000 lb but a 50 per cent increase could possibly be expected, thereby establishing a 20,000 lb design wheel load. Mr. Greer gave further information on the design of the expressways, the contracting methods, and maintenance problems. Public reaction to them had been favourable, he noted. Out of the entire 50,000 mile load system in Texas, 100 miles of fully controlled access highways were in operation and 400 to 500 miles more were in various stages of development.

Present-Day Locomotive Working in Great Britain*

No. X : KING'S CROSS–EDINBURGH NON-STOP EXPRESSES—PART I

By O. S. NOCK, B.Sc., M.I.C.E., M.I.Mech.E.

Since their first introduction by the L.N.E.R. in 1928, *the London–Edinburgh non-stop trains run during the period of the summer service have provided the longest regularly-made non-stop run anywhere in the world. Successive accelerations have brought the overall speed up to the* 1953 *maximum of* 58 *m.p.h., and in this article and a succeeding one the author analyses the performance involved and recalls the development of the service from the original* 47·6 *m.p.h. timing of* 1928.

THE operation of the London–Edinburgh non-stop expresses each summer has always provided one of the most spectacular locomotive workings to be found anywhere in the world. On its first introduction the spectacle was not that of high sustained speed. Many felt that the practical limits of a hand-fired, coal-burning steam locomotive were very nearly reached on a non-stop run of 8½ hours duration, at an average speed of 47½ m.p.h. with trains liable to be loaded up to 500 tons behind the tender. The non-streamlined "Pacific" engines of Sir Nigel Gresley's design, by their reliability as machines and by the economy of their thermodynamic performances proved, however, more than equal to the task. Naturally, picked engines and high-quality fuel were used ; but it was soon found possible to accelerate, and by the summer of 1935 the timing was down to 7½ h. The peak performance so far as pre-war running was concerned came in 1937, when the allowance was reduced to the level 7 h—an average of 56 m.p.h. The streamlined engines of the "A4" class were used on this Scottish "non-stop" for the first time that year, and the margin of power in reserve was thereby increased. In the same year, however, attention tended to be diverted from the "non-stop" to the new "Coronation" express, strictly limited in loading, but making the unprecedented time of 6 h between London and Edinburgh. With one brief stop in each direction the running average speed of the new streamlined train was 66 m.p.h. Later, a second stop was added within the schedule of the north-bound train.

Until the outbreak of war put a temporary stop to the working of the summer non-stop service, it was by that veritable institution of a train, "The Flying Scotsman," that the run was made. Since the war, however, the non-stop run has, in each direction, been made by what is virtually a "relief" to the regular train, leaving London and Edinburgh at 9.35 a.m. and 9.45 a.m. respectively. From the moment of their reintroduction these "relief" trains have been made showpieces to such an extent as to overshadow the age-old "Flying Scotsman." They took first of all the title of "The Capitals Limited," but last year, concurrently with the notable acceleration to a 6¾ h run, the name was changed to "The Elizabethan." One more point by way of historical background : travelling south recently an elderly Scottish passenger recalled the record London–Edinburgh time of 1895 on the last night of the great race to Aberdeen. In the early hours of August 22nd that year it is true that the 8 p.m. "Tourist" express from King's Cross stopped in Waverley station, Edinburgh, at 2.18 a.m.—6 h 18 min from London. Brilliant though that achievement was, it cannot be regarded as anything but a very special effort, made in the culminating excitement of the Railway Race, and at times to the discomfiture and alarm of some of the most hardened travellers. Moreover, engines were changed three times, and the longest non-stop spell was over the final stage of 124·4 miles from Newcastle to Edinburgh. Here, indeed, the North-Eastern Railway made a record that, so far as I am aware, still remains unbeaten to-day over this route : 124·4 miles in 113 min—66 m.p.h. start to stop. A happy link between past and present came in 1928, when the fireman of that record trip of 1895, T. Blades, was, as senior driver at Gateshead, chosen to work the first King's Cross–Edinburgh "non-stop" over the northern half of its journey. That the train arrived in Edinburgh 12 min ahead of time on that first journey was indeed a good augury for the new service.

Four runs made at different periods in the working of the non-stop service give a good impression of the increasingly severe demands upon locomotive power, and of these four runs summary details are given in Table I.

There is an interesting contrast between the circumstances of these four runs. On No. 1 there was no check of any kind, and the interest of the journey lay in the accuracy with which the enginemen observed the sectional times laid down from point to point. These were of great importance to ensure the train followed its correct timetable path at such large traffic centres as York and Newcastle. The power output demanded from the locomotive was rather uneven, and on this occasion adverse signals were sighted in the distance approaching York. As the London driver expressed it to me : "If we'd been a minute early we should have been stopped." The "A3" engine concerned was in good fettle, and both drivers were able to run hard or easily at will. The abbreviated log of this journey in Table II shows clearly the varying demands made by the point-to-point timings, and how closely those timings were kept.

TABLE I—*King's Cross—Edinburgh Runs*

Run No. / Date	1 August, 1935	2 September, 1936	3 August, 1951	4 June, 1953
Direction of run	Northbound	Southbound	Northbound	Southbound
Load, coaches	14	14	12	11
Gross tons behind tender	480	475	465	415
Booked speed, m.p.h.	52·4	54·2	53·6	58·2
Engine No.	2795	4474	60029	60028
Engine class	"A3"	"A1" *	"A4"	"A4"
Actual overall time, min.	447½	432¼	431½	399¼
Net running time, min.	447½	419	402	386½
Net average speed, m.p.h.	52·7	56·3	58·6	60·9

* Original Gresley "A1" class : now rebuilt to "A3."

No. 2 was not strictly a non-stop run. In the last weeks of the summer service in 1936 the train called at Newcastle, though still maintaining the overall timing of that year, 7½ hours. But although crews were changed there the engine diagrams of the non-stop period were retained and the one "Pacific" worked through from Edinburgh to London. While there was thus time to oil round at Newcastle the matter of coal supply was the same as on a non-stop run, and the London

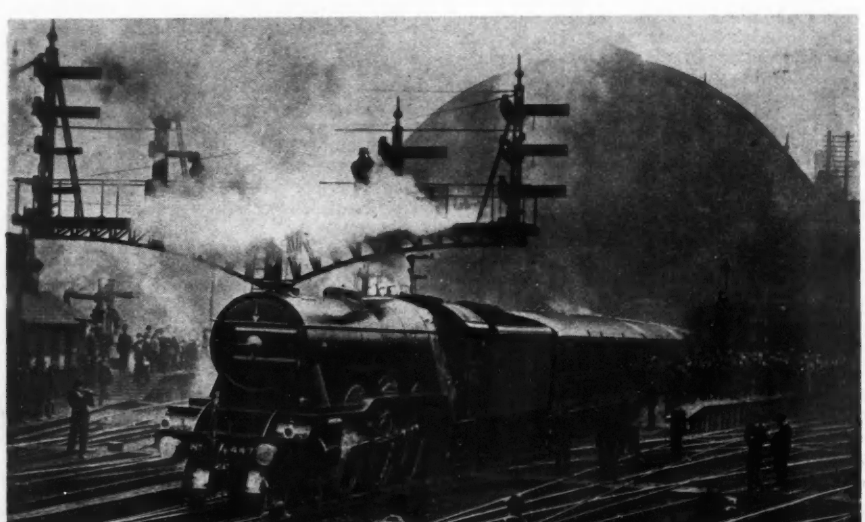


Fig. 1—The first London-Edinburgh non-stop leaving King's Cross on May 1, 1928

* Previous articles in this series were : No. I, "The L.N.E.R. 2–6–2 'Green Arrow' Class," October 11, 1946 ; No. II, "The L.M.S.R. 'Coronation' Class 'Pacifics,'" December 13 and 20, 1946 ; No. III, "The G.W.R. Oil-Fired 4–6–0s," February 6 and 13, 1948 ; No. IV, "The Mixed Traffic 4–6–0s," November 4, 11, 18 and 25, 1949 ; No. V, "The Western Region 'Castle' Class," April 20 and 27, 1951 ; No. VI, "First Results from the 'Britannias,'" April 4, 1952 ; No. VII, "The Gresley 'Pacifics' on the East Coast Route," July 18 and 25, 1952 ; No. VIII, "The Thompson and Peppercorn 'Pacifics' of the Former L.N.E.R.," May 29 and June 5, 1953 ; No. IX "The 'King' Class 4–6–0s of the Former G.W.R.," July 10 and 17, 1953.

driver and fireman who took over at Newcastle had a considerably longer spell than if they had passed through the corridor tender a few miles north of York. This again was one of those trouble-free journeys when the job looked almost easy. The day was calm and fine, and the steaming of the engine as near perfect as makes no matter. Over certain stretches the engine was run quite easily, but in accordance with timetable requirements the finish was fast, with a time of 77½ min over the concluding 76·4 miles from Peterborough to King's Cross. The engine No. 4474, "Victor Wild," was one of the original Gresley "Pacifics," with a boiler carrying no more than 180 lb per square inch pressure. It is significant that this engine was not one of those allocated to the non-stop run ; it was fitted with an ordinary, instead of a corridor, tender and therefore conveyed only 8 tons of coal, instead of 9 tons on the larger tenders specially designed for the non-stop workings. Yet on this run there was approximately a ton of coal left on arrival at King's Cross, this indicating a consumption of little more than 40 lb per mile. The log of this journey is given in Table III ; it is, I consider, a very good example of the performance of the original Gresley "Pacifics," though by that time the valve gear had been modified in the light of experience gained during the interchange trials with the Great Western Railway, in 1925. "Pacific" No. 4474 was indeed the actual engine that worked the Cornish Riviera Express between Paddington and Plymouth during those trials.

TABLE II—*The Non-Stop "Flying Scotsman" in 1935*

Distance, miles		Booked time, min	Actual time, min	Actual average speeds, m.p.h.
0·0	King's Cross	0	0	—
17·7	Hatfield	25	26	40·9
31·9	Hitchin	39	38½	66·9
58·9	Huntingdon	61	60½	74·4
76·4	Peterborough	79	78½	59·2
105·5	Grantham	114	113½	49·9
120·1	Newark	130	129	55·6
138·6	Retford	151	149½	54·2
156·0	Doncaster	170	168½	54·3
188·2	York	209	209½	47·4
210·4	Thirsk	234	233½	54·9
232·3	Darlington	256	254	64·1
254·3	Durham	282	277½	55·6
268·3	Newcastle	300	298½	40·5
284·9	Morpeth	325	322½	41·1
303·1	Alnmouth	345	341	60·0
335·2	Berwick	380	374½	57·9
351·5	Grantshouse	—	401½	35·6
363·6	Dunbar	—	413½	63·2
392·7	Edinburgh	450	447½	51·3

TABLE III—*The "Flying Scotsman,"* 1936

Distance, miles		Schedule time, min	Actual time, min	Actual average speed, m.p.h.
0·0	Edinburgh	0	0	—
29·1	Dunbar	34	31	56·3
41·2	Grantshouse	—	47	45·3
57·5	Berwick	67	63½	60·2
89·6	Alnmouth	101	99	53·7
107·8	Morpeth	121½	118½	56·0
124·4	Newcastle*	144	139½	47·9
0·0		0	0	—
14·0	Durham	20½	19½	43·6
36·0	Darlington	48	46	49·3
80·1	York	90½	88½	61·9
93·9	Selby	108	105½	49·5
112·3	Doncaster	128	125	56·7
148·3	Newark	163½	162	58·3
162·8	Grantham	179	177½	55·7
168·2	Stoke signalbox	—	185½	43·3
188·8	Werrington Junction	—	202½	71·7
191·9	Peterborough	207	205½	57·2
209·4	Huntingdon	226½	224½	56·8
236·4	Hitchin	251	249½	64·1
250·6	Hatfield	266	265½	53·3
268·3	King's Cross	286	283½	59·0

* Stop to change engine crews.

Since 1937 the working of the Edinburgh non-stops has been exclusively in the hands of the streamlined "A4" engines ; but "The Capitals Limited" was run in summers when there was not always immunity from footplate troubles, and when shy steaming engines were not unheard of. While running conditions are nowadays not always so favourable as they were in pre-war years, one aspect of the working has remained absolutely unchanged ; that aspect, I am glad to say, is the zeal of the engine crews, whether from King's Cross or Haymarket. The single aim is common to them all : the "non-stop" must be run to time, if humanly possible. This spirit was never more manifested than during the later part of the 1948 season after the unprecedented storm damage between Berwick and Dunbar that closed the line entirely for a period of approximately three months. Then the "non-stop," in common with all other East Coast expresses, was routed via Galashiels and Kelso. The mileage was increased from 392·7, via Dunbar, to 408·6, but the diversion route involved far greater difficulties than those of mere mileages. From Edinburgh the old North British main line to Carlisle, the "Waverley" route, was followed as far south as St. Boswells ; but although this is a trunk route maintained up to first-class standards, the gradients are very heavy and the curves preclude the running of high speeds in the descending directions. After turning east from this route at St. Boswells speed over the 11·3 miles of the Kelso single-line branch was limited to 25 m.p.h., and then relaxed to no more than 40 m.p.h. over the concluding stretch from Kelso to Tweedmouth Junction, 22·3 miles.

Following this route the first set of water troughs come at Lucker, 90 miles from Edinburgh, against 74 miles on the direct line through Dunbar. This in itself would tax the resource of an engine crew attempting to make a non-stop run to London, or completing the northbound run ; but the first 15 miles of the Waverley route are exceptionally difficult. A summit level of 880ft above Ordnance Datum is reached no further than 18 miles out of Edinburgh, and to reach this the line ascends for 9½ miles from Hardengreen Junction at an almost continuous inclination of 1 in 70. At that time the maximum load permitted to an unassisted "A4" engine was 400 tons. The regular coach formation of the London-Edinburgh "non-stop" exceeded this figure, and on the southbound run the temporary schedule arranged while the diversion was in progress allowed for a stop at Hardengreen Junction to take rear-end banking assistance. A further service stop was scheduled at Galashiels to take water. On the northbound run the gradients leading to Falahill summit are not so severe, and generally speaking assistance was not necessary. But a stop at Galashiels to take water was included in the temporary schedule. One would have thought that the engine crews of this train would have accepted as inevitable, in view of the most unusual circumstances, the need for the southbound "non-stop" to stop twice and the northbound train to stop once. But the emergency made all the plainer the spirit animating these enginemen.

On certain days, when the weather was favourable, and the load did not exceed by too much the official 400-ton limit, Hardengreen Junction was passed at speed and the ascent to Falahill taken without assistance. More than this, things were managed so well on the footplate that no stop for water was needed at Galashiels and the train was actually worked through non-stop from Edinburgh to London. Very little water would be used between St. Boswells and Tweedmouth, but there would still remain some 15 miles of fast running after the main line had been rejoined before the water troughs were reached. It is one of my great regrets that I was not able to travel by the train on one of these exceptional runs ; but it is a pleasure to set on record the occasions on which the non-stop London-Edinburgh run was made via Kelso and Galashiels, and the crews and engines concerned.

The honour of inaugurating this enterprising practice fell upon Driver Stevenson, of Haymarket, on the morning of Tuesday, August 24, 1948. After that he and his English partner repeated the performance—down one day and up the next—for the rest of that week. In the following week the feat was performed once only, but commenc-

TABLE IV—*Down Runs*

Date, 1948	Engine No., class "A4"	Engine name	Drivers	
			King's Cross	Haymarket
August 25th	60028	"Sea Eagle"*	Brown	Stevenson
August 26th	60027	"Merlin"	King	McLeod
August 27th	60029	"Woodcock"	Moore	Stevenson
September 2nd	60029	"Woodcock"	Moore	Stevenson
September 6th	60029	"Woodcock"	King	Swan
September 7th	60012	"Commonwealth of Australia"	Jarrett	McLeod
September 8th	60029	"Woodcock"	King	Swan
September 9th	60031	"Golden Plover"	Prinkley	McLeod

* Since renamed "Walter K. Whigham."

Fig. 2—The southbound "Flying Scotsman" in 1932 with "A3" engine "Call Boy"

TABLE V—*Up Runs*

Date, 1948	Engine No., class "A4"	Engine name	Drivers	
			King's Cross	Haymarket
August 24th	60029	"Woodcock"	Brown	Stevenson
August 26th	60028	"Sea Eagle"*	Brown	Stevenson
August 28th	60029	"Woodcock"	Moore	Stevenson
September 7th	60029	"Woodcock"	King	Swan
September 9th	60029	"Woodcock"	King	Swan
September 11th	60012	"Commonwealth of Australia"	Jarrett	Swan
September 15th	60022	"Mallard"	Burgess	Swan
September 17th	60029	"Woodcock"	Brown	Swan
September 18th	60012	"Commonwealth of Australia"	King	McLeod

* Since renamed "Walter K. Whigham."

ing on Monday, September 6th, the Haymarket driver, J. Swan, and his English partners made five non-stop runs in succession. The following is an abbreviated log of the run on September 7, 1948, when the load was 435 tons tare and 460 tons gross behind the tender:—

Miles			Actual time, min
0·0	Edinburgh (Waverley)	dep.	0
9·5	Hardengreen Junction	pass	17
17·9	Falahill Box	,,	48
33·4	Galashiels	,,	67
52·0	Kelso	,,	109
74·3	Tweedmouth Junction	,,	148

The train was delayed by signal between Tweedmouth and Darlington, and lost 6 min in running; but this was recovered, and King's Cross was reached on time, at the amended arrival time of the emergency period, that is. It will be noted, however, that a time of 31 min was spent over the 8·4 miles from Hardengreen Junction to Falahill—an average of no more than 16½ m.p.h.

To give some impression of the work involved between Edinburgh and Falahill summit I am including, in tabular form, details of a run I was privileged to note on the footplate of the "Flying Scotsman" after the winter service had commenced, but while the diversion route was still being used. With a load of 480 tons tare, and a wet rail, this was no occasion for attempting a non-stop run to Tweedmouth, the first passenger stop. Reference to Table VI, however, will show the severity of the working conditions, even though rear-end assistance was provided from Hardengreen Junction. The "banker" was an ex-N.B.R. 4–4–0 of the "Glen" class—an exceedingly capable small engine that for many years did remarkable work on the West Highland line. Such an engine could be relied upon to take a worthy share of the load up to Falahill; yet, despite this, the "A4" needed to be worked in 40 per cent cut-off. One can well appreciate what was needed on this incline when the "non-stop" was taken through without help, and can still more appreciate the good judgment and good firing necessary to make the initial 5000 gallons of water last out over the 90 miles from Edinburgh to Lucker troughs. I mention the firing particularly because more water can be used by allowing a free-steaming engine to blow off at the safety valves than by the heaviest pounding in which a driver may choose to indulge.

It will be seen that continuous working at 42 per cent cut-off from Hardengreen Junction gradually beat the boiler, and pressure dropped to 180 lb on passing Falahill summit. The regulator was full open throughout from Hardengreen.

The reaction of the engine crews of "The Capitals Limited" to unusual circumstances are summarised, in the barest details in run No. 3, in Table I. This run was made on a Monday morning, and for some reason the engine was late away from the shed. It was 13 min behind time when we left King's Cross, and as a similar delay had befallen the engine of the 9.18 a.m. express to Leeds the two trains were running close behind one another. I was on the footplate this time, and it was soon evident that the late start was not to be our only handicap. From the very start the engine was not steaming well and it was disconcerting to have the boiler pressure down to 180 lb per square inch no farther out of the terminus than Potters Bar, 12·7 miles, with the knowledge that we had a further 380 miles to go, non-stop! At first, however, our speed was governed largely by the Leeds train ahead. This was evidently not doing too well either, for in addition to several pronounced checks we were frequently seeing the distant signals pulled off ahead of us. Thus, far from recovering any of the initial lateness we took 100½ min to cover the 88·6 miles from King's Cross to Essendine, inclusive of the regular slowing through Peterborough. Then a further unexpected delay occurred. Stoke summit signalbox had sent the "stop and examine" call to Corby Glen station for a south-bound train, and at that station we were stopped, until the other train had arrived and it was safe for us to proceed.

Here was a set of circumstances enough to discourage any two engine crews. When we were signalled away the time was 11.41½ a.m.; we had 308½ min left in which to effect a punctual arrival in Edinburgh, 295·6 miles ahead, and an engine that was distinctly shy for steam. One could not say the steaming was bad; it needed constant attention to keep the pressure above 200 lb per square inch, and this on a 250 lb engine means hard and continuous work for the firemen. At Grantham, the first scheduled check point north of Corby Glen, we were 29 min late. While I had, on leaving King's Cross, looked forward with some confidence to the regaining of the original 13 min of lateness, 29 min was another matter, and running so far out of course I feared that we might experience more delays in passing through the larger traffic centres. I was wrong on both counts. First, the King's Cross crew, and later the Haymarket one, worked assiduously to regain the lost time; the operating department gave us a perfectly clear road through York and Newcastle, and the result, despite some bad spells with the steaming, was a credit to all who were concerned north of Grantham. Our progress can be most readily judged from the summary given in Table VII. The signal check at Doncaster and the permanent way slowing near Acklington (Northumberland) caused between them a further loss of 7 min, and yet, as shown in Table VII, we were no more than 4 min late on arrival in Edinburgh. Our net running time for the whole journey, as given in the comparative summary in Table I, was 402 min, an average speed throughout of 58·6 m.p.h. and a gain of 38 min on the schedule time then in force. On the other hand, the run was not made non-stop, and the 5¼ min wait at Corby Glen had allowed the boiler pressure to be rallied from a flagging 170 lb to a full 250 lb before we started again. But it was a performance in which Driver Simmonds and Fireman Hemmings, of King's Cross, and Driver Anderson and Fireman Inglis, of Haymarket, more than upheld the traditions of the "non-stop."

(To be continued)

TABLE VII—*Northbound Run, August,* 1951

Check points	Miles, point to point	Booked time, point to point (min)	Booked speed, m.p.h.	Actual speed, m.p.h.	Time, a.m. or p.m.	Mins late
Grantham	—	—	—	—	11.54½	29
Retford	33·1	32½	61·2	66·5	12.24½	26
Doncaster	17·4	21	49·8	54·8*	12.43½	24
Selby	18·4	19	58·0	63·3	1.1	22½
York	13·8	17	48·7	51·8	1.17	21½
Northallerton	30·0	29	62·1	60·7	1.46½	22
Darlington	14·1	13	65·0	64·0	1.59½	22
Durham	21·9	24	54·8	58·8	2.22	20½
Newcastle	14·1	19	44·6	53·8	2.38	17½
Morpeth	16·6	22	45·3	47·0	3.0	17½
Alnmouth	18·2	18	60·7	54·8*	3.20	19½
Belford	16·8	17	59·3	60·2	3.36½	19
Berwick	15·3	15	61·2	64·1	3.51	18½
Grantshouse	16·3	29†	33·7	45·7	4.12½	11
Dunbar	12·1	11	66·0	62·0	4.23½	11
Drem Junction	11·3	10½	64·7	66·7	4.33½	10½
Portobello	14·8	21½‡	42·3	56·0	4.49½	5½
Edinburgh	3·0	6	30·0	36·0	4.54½	4½

* Checks at Doncaster and Acklington
† Includes recovery time.
‡ Includes allowance for pitfall slack.

TABLE VI—"*Flying Scotsman*"—*Diversion Route*

Engine "A4" class, 4-6-2, No. 60027, "Merlin." Load 515 tons.

Distance, miles		Gradient	Time, min sec	Average speed, m.p.h.	Boiler pressure, p.s.i.	Cut-off, per cent
0·0	Edinburgh	—	0 00	—	—	—
3·0	Portobello *	Down hill	5 52	30·7	240	40
4·5	Niddrie South Junction	1 in 80	9 20	26·0	230	35
—		Level	—	—	—	—
6·0	Millerhill	1 in 175	12 10	23·5	225	30
8·0	Eskbank	1 in 230	15 35	35·3	230	35
8·2	Hardengreen Junction †	1 in 228	16 35	—	—	—
			arr.			
			dep.			
9·7	Newtongrange	1 in 70	21 49	27·2	230	42
12·0	Gorebridge	1 in 70	27 18	25·1	220	42
—		1 in 70	—	—	—	—
12·7	Fushiebridge	1 in 111	28 54	26·3	215	42
14·4	Borthwick Bank	1 in 70	32 34	27·8	205	42
16·0	Tynehead	1 in 70	36 48	22·6	205	42
17·9	Falahill Box ‡	1 in 100	41 47	22·8	180	42

* Speed restriction 25 m.p.h.
† Bank engine, "Glen," 4–4–0 type, attached in rear.
‡ Summit: 880ft above Ordnance Datum.

Losses in Prestressed Concrete Beams

By Dr. HENRY J. COWAN

Precompression, shrinkage and creep are the three principal causes of loss of prestress in prestressed concrete beams. Losses are calculated for uniformly pretensioned beams not carrying their own weight, for eccentrically pretensioned beams carrying their own weight and for post-tensioned beams.

THERE are three prinoipal causes for the loss of prestress observed in pretensioned concrete beams. Shrinkage of the concrete, resisted by the tensioned steel, produces tensile stresses in the concrete, frequently resulting in the formation of fine cracks. When the prestress is released from the anchorages and transferred to the concrete, the shrinkage cracks are closed and the tensile stresses eliminated ; the prestressing force is reduced accordingly. There is a further loss due to " precompression " of the concrete, i.e. due to the elastic contraction caused by the stressing of the concrete on transfer.

The principal loss after release from the anchorages is due to creep of the concrete under the action of the prestressing force. This loss continues during the useful life of the structure, and allowance must therefore be made for the full loss corresponding to the ultimate creep of the concrete.

The losses on transfer are generally avoided in post-tensioned beams. Since the concrete forms the anchorage during the prestressing operation, there is no loss due to precompression. If an adequate period is allowed to elapse between the casting and the stressing, most of the shrinkage will have occurred before the beams are tensioned. An allowance for the residual shrinkage can be included in the constant for the ultimate creep of the concrete.

Losses in Uniformly Pretensioned Beams Not Carrying Their Own Weight

Loss of Prestress on Transfer.—The steel is tensioned against external anchorages by an initial prestressing force P_i, producing a stress f_{si} in the steel, before the concrete is cast.

During the curing process the length of the concrete beam L is reduced through shrinkage by sL. This shortening is resisted by the steel, and therefore sets up tensile stresses in the concrete which are frequently relieved by the formation of cracks.

On release from the external anchorages the prestressing force is transferred to the concrete, producing a uniform compressive stress f_{cr}. The prestressing force is reduced to P_r, and the stress in the steel to f_{sr}.

Since the forces in the steel and the concrete must balance for internal equilibrium,

$$P_r=f_{cr}A_c=f_{sr}A_s \quad . \quad . \quad . \quad . \quad (1)$$

Defining the steel ratio $r=A_s/A_c$,

$$f_{cr}=rf_{sr} \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Provided the wires do not slip during transfer, the shortening of the concrete due to shrinkage and precompression is equal to the shortening of the steel.

$$sL+e_{cr}L=(e_{si}-e_{sr})L$$

If both steel and concrete deform elastically,

$$s+f_{cr}/E_c=(f_{si}-f_{sr})/E_s \quad . \quad . \quad . \quad (3)$$

Defining the modular ratio $m=E_s/E_c$,

$$E_s s+mf_{cr}=f_{si}-f_{sr} \quad . \quad . \quad . \quad (4)$$

Substituting from equation (2) the stress produced in the concrete on transfer

$$f_{cr}=r(f_{si}-E_s s)/(1+mr) \quad . \quad . \quad . \quad (5)$$

and the stress remaining in the steel

$$f_{sr}=(f_{si}-E_s s)/(1+mr) \quad . \quad . \quad . \quad (6)$$

The percentage loss of prestress on transfer is

$$\frac{f_{si}-f_{sr}}{f_{si}}\times 100=\frac{mr+E_s s/f_{si}}{1+mr}\times 100 \text{ per cent} \quad . \quad (7)$$

Loss of Prestress After Transfer.—The loss after transfer is mainly caused by the gradual contraction of the concrete due to creep under the sustained action of the prestressing force, which is consequently reduced from P_r to P_f.

Since the elastic change in the length of the steel must equal the total change in the length of the concrete due to elastic deformation and creep,

$$-\delta e_s L=\delta e_c L+f_c\,\delta c L,$$

where e_s and e_c are the elastic strains in the concrete after a time interval, and c is the creep of the concrete per unit stress, assumed to be directly proportional to the stress.

If f_s is the corresponding stress in the steel

$$-\delta f_s/E_s=\delta f_c/E_c+f_c\delta c \quad . \quad . \quad . \quad (8)$$

Furthermore the changes in the internal forces in the steel and concrete must balance.

$$\delta f_s A_s=\delta f_c A_c \quad . \quad . \quad . \quad . \quad (9)$$

Putting $m=E_s/E_c$ and $r=A_s/A_c$, and substituting into equation (8),

$$-\delta f_c/mr=\delta f_c+E_c f_c\delta c. \quad . \quad (10)$$

While the creep per unit stress increases from o to c in a time interval, the concrete stress f_c decreases from f_{cr} to f_{cf}.

$$\int_{f_{cr}}^{f_{cf}}\frac{df_c}{f_c}=-\frac{E_c mr}{1+mr}\int_0^c dc$$

Putting $\alpha=(1+mr)/E_s r$,

$$\log_e\frac{f_{cf}}{f_{cr}}=-\frac{c}{\alpha}.$$

The final prestress in the concrete is therefore

$$f_{cf}=f_{cr}e^{-c/\alpha} \quad . \quad . \quad . \quad . \quad (11)$$

and the final prestress in the steel

$$f_{sf}=f_{sr}e^{-c/\alpha} \quad . \quad . \quad . \quad . \quad (12)$$

where e is the base of the natural logarithm.

The percentage loss of prestress after transfer is

$$\frac{f_{sr}-f_{sf}}{f_{sr}}\times 100=(1-e^{-c/\alpha})\times 100 \text{ per cent} \quad . \quad (13)$$

Example 1.—A symmetrical concrete I-section, with dimensions as shown in Fig. 1, is pretensioned by forty 12 S.W.G. wires, equally divided between the top and bottom flanges. The initial prestress is 160,000 lb per square inch. Calculate the prestress after transfer and the final prestress, if the beam does not carry its own weight after transfer. The shrinkage of the concrete per unit length is 3×10^{-4} and its ultimate specific creep is 4×10^{-7} per pound per square inch. The moduli of elasticity of the steel and the concrete are 28×10^6 and 4×10^6 lb per square inch respectively.

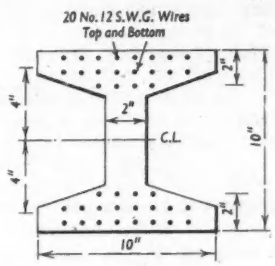


Fig. 1

The cross-sectional areas of the steel and the concrete are $A_s=0\cdot340$ square inch and $A_c=52\cdot0$ square inches, and the steel ratio is therefore $r=0\cdot340/52\cdot0=0\cdot00654$.

The modular ratio $m=28\times10^6/4\times10^6=7$.

From equation (6) the stress remaining in the steel after transfer

$$f_{sr}=(160{,}000-28\times10^6\times3\times10^{-4})/(1+7\times0\cdot00654)$$
$$=145{,}000 \text{ lb per square inch}$$

and the loss of prestress on transfer is 9·4 per cent.

The constant $\alpha=(1+7\times0\cdot00654)/28\times10^6\times0\cdot00654=5\cdot71\times10^{-6}$; the ratio $c/\alpha=4\times10^{-7}/5\cdot71\times10^{-6}=0\cdot070$; and the exponential function $e^{-c/\alpha}=0\cdot932$.

From equation (12) the final steel stress is therefore $f_{sf}=145{,}000\ \ 0\cdot932=13{,}5000$ lb per square inch, and the loss of prestress after transfer is 6·8 per cent.

The total loss of prestress is 15·6 per cent.

Losses in Eccentrically Pretensioned Beams Carrying Their Own Weight

In practice the prestressing force is normally applied eccentrically, thus giving rise to a non-uniform distribution of prestress in the concrete. Allowance must also be made for the effect of the dead load, which remains constant while the prestressing force is being reduced by the creep of the concrete.

Loss of Prestress on Transfer.—On release from the external anchorages the initial prestressing force

$$P_i=f_{si}A_s$$

is reduced by shrinkage and precompression to

$$P_r=f_{sr}A_s \quad . \quad . \quad . \quad . \quad (14)$$

At the same time stresses varying from f_{crB} at the bottom face of the beam to f_{crT} at the top face are induced in the concrete. These stresses are often entirely compressive ; small tensile stresses, distinguished by a negative sign, are, however, admissible. If ϵ denotes the eccentricity of the prestressing force, i.e. the distance of the centroid of the steel section from the centroid of the concrete section

$$f_{crB,T}=\frac{P_r}{A_c}\pm\frac{P_r\epsilon}{Z_{B,T}} \quad . \quad . \quad . \quad . \quad (15)$$

where Z_B and Z_T are the section moduli with reference to the bottom and top faces.

If I_c is the second moment of area of the section shown in Fig. 2,

$$Z_B=I_c/h_B \text{ and } Z_T=I_c/h_T$$

The stress in the concrete immediately surrounding the prestressing steel

$$f_{cr}=\frac{P_r}{A_c}+\frac{P_r\epsilon^2}{I_c}=f_{sr}\frac{A_s}{A_c}\left(1+\frac{\epsilon^2}{k^2}\right) \quad . \quad . \quad (16)$$

Notation

A_c, A_s—Cross-sectional area of concrete, of steel.
c—Ultimate creep per unit stress per unit length.
e—Base of natural logarithm.
e_c, e_s—Concrete, steel strain.
e_{si}—Initial steel strain induced by pretensioning.
e_{cr}, e_{sr}—Concrete, steel strain after transfer.
E_c, E_s—Modulus of elasticity of steel, of concrete.
f_c, f_s—Concrete, steel stress.
f_{si}—Initial steel stress of pretensioned beam.
f_{cr}, f_{sr}—Concrete, steel stress after transfer.
f_{cf}, f_{sf}—Concrete, steel stress after loss due to creep.
f_{cB}, f_{cT}—Concrete stress at bottom, top face of beam.
I_c—Second moment of area of concrete section.
k—Radius of gyration of concrete section $=\sqrt{I_c/A_c}$.
K, K_1, K_2—Constants.
L—Span of beam.
m—Modular ratio, $=E_s/E_c$.
M_D—Maximum bending moment due to weight of beam.
P_i—Initial prestressing force on pretensioned beam.
P_r—Prestressing force after transfer.
P_f—Prestressing force after loss due to creep.
r—Steel ratio, $=A_s/A_c$.
s—Shrinkage per unit length.
Z_B, Z_T—Section modulus referred to bottom, top face of beam.
α, β, γ—Constants.
ϵ—Eccentricity of prestressing force at midspan.

where $k=\sqrt{I_c/A_c}$ is the radius of gyration of the concrete section.

The shortening of the steel on transfer must equal the shortening of the surrounding concrete due to shrinkage and precompression.

$$s+\frac{f_{cr}}{E_c}=\frac{f_{si}-f_{sr}}{E_s} \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Substituting for f_{cr} from equation (16),

$$E_s s+\frac{E_s}{E_c}f_{sr}\frac{A_s}{A_c}\left(1+\frac{e^2}{k^2}\right)=f_{si}-f_{sr}$$

Therefore the stress remaining in the steel after transfer

$$f_{sr}=\frac{f_{si}-E_s s}{1+mr(1+e^2/k^2)} \quad . \quad . \quad (17)$$

and the percentage loss of prestress on transfer

$$\frac{f_{si}-f_{sr}}{f_{si}}\times 100$$

$$=\frac{mr(1+e^2/k^2)+E_s s/f_{si}}{1+mr(1+\Sigma^2/k^2)}\times 100 \text{ per cent} \quad . \quad (18)$$

The concrete stresses after transfer may be obtained from equation (15), where $P_r=f_{sr}A_s$ is given by equation (17).

Loss of Prestress after Transfer.—The prestress is reduced further after transfer by

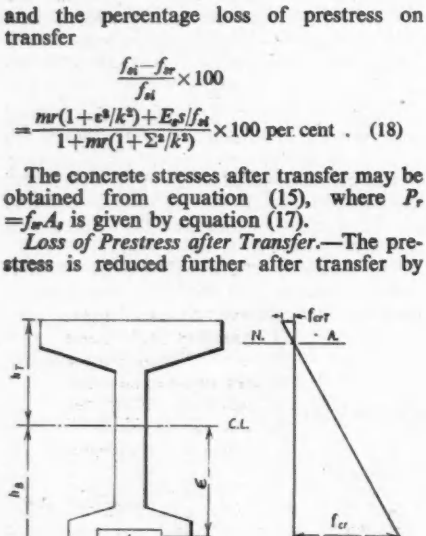


Fig. 2

creep under the combined action of the eccentric prestressing force and the bending moment due to the weight of the beam. The live load is assumed to act only for short periods, and it does not therefore influence the losses due to creep.

Since the reduction in the length of the steel and the surrounding concrete must be the same,

$$-\delta f_s/E_s=\delta f_c/E_c+f_c\delta c \quad . \quad . \quad . \quad (8)$$

The stress in the concrete surrounding the steel, f_c, due to an eccentric prestressing force f_sA_s and a dead load bending moment M_D is given by

$$f_c=\frac{f_sA_s}{A_c}+\frac{f_sA_se^2}{I_c}-\frac{M_De}{I_c} \quad . \quad . \quad (19)$$

provided the bending moments due to the prestressing force and the dead weight are of opposite sign, as is normally the case.

Substituting $r=A_s/A_c$ and $k=\sqrt{I_c/A_c}$,

$$f_c=f_sr(1+e^2/k^2)-M_De/I_c \quad . \quad . \quad (20)$$

A small change in the concrete stress

$$\delta f_c=\delta f_sr(1+e^2/k^2) \quad . \quad . \quad . \quad . \quad (21)$$

since the dead load moment may be assumed to remain unchanged during the useful life of the structure.

Substituting equations (20) and (21) into equation (8),

$$-\delta f_s/E_s=mr(1+e^2/k^2)\delta f_s/E_s$$
$$+r(1+e^2/k^2)f_s\delta c-M_De\delta c/I_c$$

Putting

$$\beta=\frac{1+mr(1+e^2/k^2)}{E_sr(1+e^2/k^2)} \text{ and } \gamma=\frac{M_De}{I_sr(1+e^2/k^2)},$$

this equation may be written

$$-\beta\delta f_s=f_s\delta c-\gamma\delta c.$$

The creep per unit stress increases from o to c in a time interval, while the steel stress decreases from f_{sr} to f_{sf}.

$$\int_{f_{sr}}^{f_{sf}}\frac{df_s}{f_s-\gamma}=\int_0^c-\frac{dc}{\beta}$$

The solution of this equation is

$$\frac{f_{sf}-\gamma}{f_{sr}-\gamma}=e^{-c/\beta} \quad . \quad . \quad (22)$$

Therefore the final prestress in the steel

$$f_{sf}=f_{sr}\,e^{-c/\beta}+\gamma(1-e^{-c/\beta}) \quad . \quad (23)$$

and the percentage loss of prestress

$$\frac{f_{sr}-f_{sf}}{f_{sr}}\times 100=(1-e^{-c/\beta})\,.\,(1-\gamma/f_{sr})$$
$$\times 100 \text{ per cent} \quad . \quad . \quad . \quad . \quad (24)$$

The final stresses at the bottom and top faces of the concrete section

$$f_{cfB,T}=\frac{P_f}{A_c}\pm\frac{P_fe}{Z_{B,T}} \quad . \quad . \quad . \quad . \quad (25)$$

where $P_f=f_{sf}A_s$ is the final prestressing force.

Example 2.—The symmetrical concrete I-section shown in Fig. 3 is pretensioned by twenty 12 S.W.G. wires in the bottom flange, initially prestressed to 160,000 lb per square inch. The beam lifts off its support on transfer, and thereafter supports its own weight over a span of 20ft. Calculate the

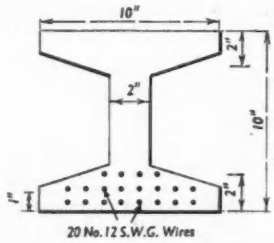


Fig. 3

prestress after transfer, if the properties of the steel and the concrete are the same as in example 1.

The cross-sectional areas of the steel and the concrete are $A_s=0{\cdot}170$ square inch and $A_c=52{\cdot}0$ square inches, and the steel ratio is therefore $r=52{\cdot}0/0{\cdot}170=0{\cdot}00327$.

The second moment of area of the concrete section is $I_c=689$ in.^{4}, and its radius of gyration $k=\sqrt{689/52{\cdot}0}=3{\cdot}64$in.

The modular ratio $m=28\times10^6/4\times10^6=7$.

The eccentricity of the prestressing force $e=5-1=4$in.

The term $r(1+e^2/k^2)-0{\cdot}00723$ and the term $1+mr(1+e^2/k^2)=1{\cdot}050$.

From equation (17) the steel stress remaining after transfer $f_{sr}=(160{,}000-28\times10^6\times3\times10^{-6})/1{\cdot}050=144{,}200$ and the loss of prestress on transfer is 9·9 per cent.

The constant $\beta=1{\cdot}050/28\times10^6\times0{\cdot}00723=5{\cdot}18\times10^{-6}$; the ratio $c/\beta=4\times10^{-7}/5{\cdot}43\times10^{-6}=0{\cdot}077$; the exponential function $e^{-c/\beta}=0{\cdot}926$.

Taking the weight of concrete as 144 lb per cubic foot, the maximum bending moment due to the weight of the beam over a span of 20ft is $M_D=52\times20^2\times12/8=31{,}200$ lb-in. Therefore, $\gamma=31{,}200\times4/689\times0{\cdot}00723=25{,}000$ lb per square inch.

From equation (23) the final steel stress $f_{sf}=144{,}200\times0{\cdot}926+25{,}000\times0{\cdot}074=135{,}600$ lb per square inch and the loss of prestress after transfer is 6·0 per cent

The total loss of prestress is 15·3 per cent.

Losses in Post-Tensioned Beams

The computation of the loss of prestress in post-tensioned beams is basically the same as for pretensioned beams. Since the concrete forms the anchorage during the prestressing operation, there is no loss due to precompression. It is advisable to delay prestressing until most of the shrinkage has taken place, and creep losses only need then be computed. Some allowance for the residual shrinkage can be made by using a slightly higher creep constant.

If the steel is effectively bonded to the concrete by grouting after the completion of the prestressing operation, the change in the steel strain is the same as the change in

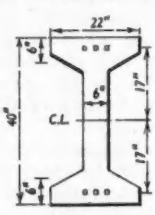


Fig. 4

the strain in the surrounding concrete, and the final prestress follows from equation (12) (for uniformly prestressed beams) or equation (23) (for eccentrically prestressed beams), derived in the preceding section.

Example 3.—A symmetrical concrete I-section, with dimensions as shown in Fig. 4, is post-tensioned by six cables, each containing sixteen 0·2in diameter wires, equally divided between the top and bottom flanges. The initial prestress is 135,000 lb per square inch. Calculate the final prestress if the beam does not carry its own weight and the cables are grouted after the completion of the prestressing operation. The moduli of elasticity of the steel and the concrete are 28×10^6 lb and 4×10^6 lb per

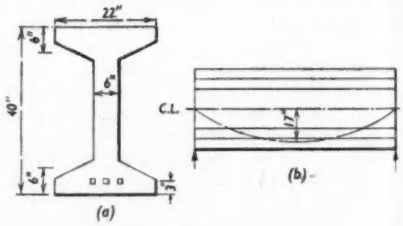


Fig. 5

square inch respectively, and the ultimate specific creep of the concrete is 4×10^{-7} per pound per square inch.

The cross-sectional areas of the steel and the concrete, allowing for the cable ducts, are $A_s=3{\cdot}02$ square inches and $A_c=408$ square inches, and the steel ratio is therefore $r=3{\cdot}02/408=0{\cdot}00740$.

The modular ratio $m=28\times10^6/4\times10^6=7$.

The constant $\alpha=(1+7\times0{\cdot}00740)/28\times10^6\times0{\cdot}00740=5{\cdot}07\times10^{-6}$; the ratio $c/\alpha=4\times10^{-7}/5{\cdot}07\times10^{-6}=0{\cdot}079$, and the exponential function $e^{-c/\alpha}=0{\cdot}924$.

From equation (12) the final steel stress is therefore $f_{sf}=135{,}00\times0{\cdot}924=124{,}800$ lb per square inch and the loss of prestress is 7·6 per cent.

Example 4.—The symmetrical concrete I-section shown in Fig. 5 is post-tensioned by three cables, each containing sixteen 0·2in diameter wires, in the bottom flange, initially prestressed to 135,000 lb per square inch. The beam lifts off its support during

the prestressing operation, and thereafter supports its own weight over a span of 50ft. Calculate the final prestress if the cables are grouted after the completion of the prestressing operation. The properties of the steel and the concrete are the same as in example 3.

The cross-sectional areas of the steel and the concrete, allowing for the cable ducts, are $A_s=1\cdot51$ square inches and $A_c=417$ square inches, and the steel ratio is therefore $r=1\cdot51/417=0\cdot00363$.

The second moment of area of the concrete section $I_c=83{,}000\text{in.}^4$, and its radius of gyration $k=14\cdot1$in.

The modular ratio $m=7$.

Due to the symmetry of the cable ducts the depth of the centroid of the section is 20·5in, and the eccentricity of the prestressing force is therefore $e=20\cdot5-3\cdot0=17\cdot5$in.

The term $r(1+e^2/k^2)=0\cdot00922$; the constant $\beta=(1+7\times0\cdot00922)/28\times10^6\times0\cdot00922=4\cdot12\times10^{-6}$; the ratio $c/\beta=4\times10^{-7}/4\cdot12\times10^{-6}=0\cdot097$, and the exponential function $e^{-c/\beta}=0\cdot908$.

Taking the weight of concrete as 144 lb per cubic foot, the maximum bending moment due to the weight of the beam over a span of 50ft is $M_D=417\times50^2\times12/8=1{,}565{,}000$ lb-in. Therefore, $\gamma=1{,}565{,}000\times17\cdot5/83{,}000\times0\cdot00922=35{,}800$ lb per square inch.

From equation (23) the final steel stress is therefore $f_{sf}=135{,}000\times0\cdot908\times35{,}800\times0\cdot092=125{,}900$ lb per square inch, and the loss of prestress is 6·7 per cent.

If the prestressing cables or bars are not bonded, the stress in the steel is uniform between the anchorages, whereas the stress in the surrounding concrete varies with the eccentricity of the prestressing force and the dead load bending moment. Equation (8) then becomes

$$-\frac{\delta f_s}{E_s}L=\int_{-\frac{1}{2}L}^{+\frac{1}{2}L}\frac{\delta f_c}{E_c}dx+\int_{-\frac{1}{2}L}^{+\frac{1}{2}L}f_c\delta c\,dx \quad . \quad (26)$$

where L is the span of the beam.

Putting

$$K_1=\frac{\int_{-\frac{1}{2}L}^{+\frac{1}{2}L}e_s^2dx}{e^2L} \text{ and } K_2=\frac{\int_{-\frac{1}{2}L}^{+\frac{1}{2}L}M_se_s dx}{M_De L}$$

(where e_s and M_s are the eccentricity of the prestressing force and the deadweight bending moment at some distance x along the beam, and e and M_D are their maximum values at midspan), and substituting from equations (20) and (21) into equation (26),

$$-\delta f_s/E_s=mr(1+K_1e^2/k^2)\delta f_s/E_s+r(1+K_1e^2/k^2)f_c\delta c-K_2M_De\delta c/I_c.$$

Putting

$$\beta=\frac{1+mr(1+K_1e^2/k^2)}{E_sr(1+K_1e^2/k^2)} \text{ and } \gamma=\frac{K_2M_De}{I_cr(1+K_1e^2/k^2}$$

gives

$$-\beta\delta f_s=f_c\delta c-\gamma\delta c$$

and the solution is therefore given by equations (23) to (25) as for beams with bonded cables ; the constants β and γ, however, have slightly different values.

In simply supported beams the eccentricity normally varies from a maximum at midspan to nil at the supports. The cables or bars then follow a flat curve, which is approximately parabolic. Since the beam is of approximately uniform cross section, the bending moment due to its own weight also varies parabolically from a maximum at midspan to nil at the ends. The constants K_1 and K_2 are then equal.

$$K=K_1=K_2=\frac{2}{L}\int_0^{\frac{1}{2}L}[1-4x^2/L^2]^2dx$$

$$=\frac{2}{L}\left(\frac{L}{2}-\frac{L}{3}+\frac{L}{10}\right)=\frac{8}{15}.$$

Example 5.—Calculate the final prestress for the beam considered in example 4, if the cables are not grouted.

Assuming the cables are approximately parabolic, $K=K_1=K_2=8/15$, and the ratio $r(1+Ke^2/k^2)=0\cdot00363\ (1+8/15\times17\cdot5^2/14\cdot1^2)=0\cdot00660$.

The constant $\beta=(1+7\times0\cdot00660)/28\times10^6\times0\cdot00660=5\cdot65\times10^{-6}$; the ratio $c/\beta=4\times10^{-7}/5\cdot65\times10^{-6}=0\cdot071$; and the exponential function $e^{-c/\beta}=0\cdot931$.

Furthermore, $\gamma=8/15\times1{,}565{,}000\times17\cdot5/83{,}000\times0\cdot00660=26{,}600$ lb per square inch.

From equation (23) the final steel stress is therefore $f_{sf}=135{,}000\times0\cdot931+26{,}600\times0\cdot069=127{,}600$ lb per square inch and the loss of prestress is 5·5 per cent.

Conclusion

Precompression, shrinkage and creep are the three principal causes of loss of prestress. In many beams there are some additional losses which are not easily assessed by theoretical methods. If the steel is in the form of wires, there is necessarily some slip at the ends. In addition to the creep in the concrete, the creep in the steel requires some consideration.* In post-tensioned beams there is generally some loss due to friction between the steel and the walls of the ducts.†

Allowances of 25 per cent for pretensioned beams, and 15 per cent for post-tensioned beams are widely used by designers for the total loss of prestress. These allowances are evidently conservative.

* Professor C. Magnel ("Le fluage des aciers et son importance en beton preconstraint," *Sci. et Tech.*, 1945, No. 2) states that this loss is negligible if the steel is overstressed by 10 per cent for a short duration.

† Losses due to friction have recently been investigated by E. H. Cooley at the Cement and Concrete Association Research Laboratory.

Machinery of the "Orsova"

The passenger liner "Orsova," which joined the fleet of the Orient Steam Navigation Company, Ltd., earlier this year, has a gross registered tonnage of 28,790, and carries 681 first-class passengers and 813 tourist-class passengers. The ship has a service speed of 22·5 knots and is propelled by two sets of geared turbines developing a normal power of 34,000 s.h.p., and taking superheated steam at 500 lb per square inch and 850 deg. Fah. from three watertube boilers. Three 1200kW turbine-driven generators supply the electrical power for the various ship's services, deck and auxiliary machinery.

THE Orient liner "Orsova," the hull, accommodation and equipment of which were described in an article which appeared in our issue of June 25th, is propelled at a service speed of 22·5 knots by two sets of double reduction geared Parsons turbines of "Pametrada" design. Each set of machinery consists of h.p., i.p. and l.p. turbines working in series and driving a single propeller. The machinery was constructed at the Barrow works of the shipbuilders, Vickers-Armstrongs, Ltd., to Lloyd's special survey and to the requirements of the Ministry of Transport for a passenger certificate, and develops a total normal power of 34,000 s.h.p. with the propellers turning at 130 r.p.m. and is capable of developing an overload of 42,500 s.h.p. at 140 r.p.m. of the propellers. Steam is supplied at a pressure of 500 lb per square inch gauge and a temperature of 850 deg. Fah.

On account of the high initial steam temperature the casings of the h.p. ahead turbines are of molybdenum alloy cast steel and the turbines are of impulse reaction type, the first stage consisting of an impulse wheel having two rows of blades, and the remaining stages twenty-nine rows of end-tightened reaction blading mounted on a solid forged steel drum. Forged steel nozzle plates, with Hecla A.T.V. steel vanes pinned in at the rings, are fitted. All reaction blading is fitted in the i.p. ahead turbines, which are housed in cast steel casings and which have thirty-five rows of end-tightened blades segmentally fitted on a hollow forged steel drum rotor. Both the h.p. and i.p. ahead turbines are fitted with thrust dummies, while Michell thrust bearings carry any unbalanced axial thrust. Cast iron casings house the double flow l.p. ahead turbines, which have eleven rows of segmental reaction blading, in each half, mounted on a hollow forged steel drum rotor. At least 65 per cent of the normal ahead power of 34,000 s.h.p. can be developed by the astern turbines, which are impulse machines, each h.p. astern turbine consisting of a three-row wheel shrunk on to each i.p. rotor shaft and incorporated in the i.p. ahead turbine casings. A forged steel three-row impulse wheel secured to the forward end of the l.p. ahead rotor forms the l.p. stage of the astern turbine, which has a cast steel casing. Both the h.p. and l.p. astern turbines have cast steel nozzle plates with vanes of Hecla A.T.V. steel.

All the impulse blading is of Hecla A.T.V. steel, while all reaction blading is of Monel metal with the exception of the last two rows of each flow on the l.p. rotor, which are of stainless iron. At each end of each turbine casing there are double pocket steam glands, the inner pockets being connected to steam receivers and the outer pockets to Weir's gland steam condensers. Two of these are fitted and each is capable of handling the vapour from one set of turbines and of maintaining a vacuum ample enough to evacuate the most remote gland pocket. The gland condenser and ejector condenser are arranged in the same casing. In the event of the turbine revolutions exceeding a predetermined figure steam is shut off from the turbines by Aspinall cut-out governors. Two other eventualities also cause the steam to be shut off automatically from the turbines, namely, any undue drop in the lubricating oil pressure, and any fore and aft movement of the h.p., i.p. and l.p. rotors exceeding a predetermined amount. We include an illustration of the manœuvring platform in the engine-room.

Gearing

Each h.p. ahead turbine drives through double reduction gearing consisting of an independent primary set of gears driving a secondary pinion on to the main wheel. The gearing for the i.p. and l.p. ahead turbines is a single reduction design. A flexible claw coupling connects each turbine to the double helical gearing. The primary gearing for the h.p. turbine, which runs at 3600 r.p.m., is enclosed in a cast iron gear case bolted to the main gear case. The gearing consists of a pinion of nickel steel having a pitch circle diameter of 13·71in and a face width of 31in, and a forged steel wheel of 34·49in pitch circle diameter with a 3in gap. Efficient lubrication of the gearing and bearings is provided in the arrangement. All the secondary pinions have central bearings and all are enclosed in a cast iron gear case; the h.p. pinions have a pitch circle diameter of 17·02in and the corresponding diameter for both the i.p. and l.p. pinions is 12·62in. The main gear wheels have a pitch circle diameter of 174·09in with a face width of 49in and cast iron centres with shrunk-on forged steel rims, while the pinions are of nickel steel. The bearing bushes are independent

Engine-room manœuvring platform illustrating the ample space available

castings and are arranged for easy removal without having to lift the main gear case cover. With the h.p. turbine running at 3600 r.p.m. and the i.p. and the l.p. turbines running at 1931 r.p.m. the gear ratio reduces these speeds to a propeller shaft speed of 140 r.p.m., corresponding to a developed horsepower of 42,500 s.h.p.

Three "Vertoil" electrically-driven pumps, two working and one standby, each capable of delivering 25,000 gallons per hour against a discharge pressure of 55 lb per square inch, lubricate the turbines and gearing. The pumps draw the lubricating oil through magnetic filters and discharge through Autoklean "Flush Flo" strainers fitted with a self-cleaning device which renders the strainer non-chokeable and ensures a small pressure drop. From the strainers the oil passes through three Serck oil coolers, two working and one standby, to gravity tanks which are of sufficient capacity to ensure a seven minutes' supply of lubricating oil to turbines and gearing in the event of a complete failure of the pumps. There are also two electrically-driven Alfa Laval lubricating oil purifiers, each having a capacity of 350 gallons per hour and associated with steam heaters. All the propeller shafting is of solid forged steel, the intermediate shafting having a diameter of 21$\frac{7}{8}$in, while the propeller shaft diameter is 23$\frac{5}{8}$in. A Michell thrust block takes the propeller thrust and the shafting is carried in Michell self-lubricating pivoted bearings. The Manganese Bronze and Brass Company, Ltd., manufactured the solid, four-bladed manganese-bronze propellers of scimitar design, which have a diameter of 18ft 9in.

Boiler Plant

Three two-furnace, controlled superheat, oil-fired Foster Wheeler water-tube boilers provide all the necessary steam and are designed for a steam pressure of 525 lb per square inch gauge and a temperature of 850 deg. Fah. at the superheater outlet. The boilers are arranged to give superheat control down to 600 deg. Fah. when manœuvring and the steam drums, which are seamless, hollow forged steel shells with closed ends, are fitted with low level alarms and externally operated oil fuel safety shut-off gear supplied by G. and J. Weir, Ltd. The illustration which we reproduce gives a view of the stokehold and of the boiler fronts.

Each boiler has a generating surface of 13,185 square feet, a waterwall heating surface of 920 square feet associated with an economiser heating surface of 17,750 square feet to give a total surface of 31,855 square feet. The superheater has a surface of 2525 square feet and the boilers are fitted with cast iron gilled economisers arranged for an inlet feed water temperature of 240 deg. Fah. and an outlet temperature of about 375 deg. Fah. All three boilers are equipped with a "Weldex" bled steam air heater supplied by the Wellington Tube Works, Ltd., which provides all the heat required for air preheating and avoids the choking by soot which has been experienced by gas heaters mainly due to the quality of the fuel oil. The duty of each heater, which can be seen in our illustration on the intake side of the forced draught fan, is to raise the temperature of 166,000 lb of air per hour from 80 deg. to 210 deg. Fah.; the steam condensed for this duty is 5360 lb per hour when supplied at 35 lb per square inch absolute and 313 deg. Fah. For dealing with overloads each heater is fitted with a by-pass capable of handling about 25 per cent excess air. The gilled tube elements, which consist of steel boiler tube and flat steel gills, are mounted vertically and welded into headers which form the steam and condensate sections.

When the machinery is developing normal power of 34,000 s.h.p., each boiler has an evaporation of 130,000 lb per hour; the maximum rate is 165,000 lb per hour. The outboard or saturated furnace, which has five burners and a combustion chamber volume of 870 cubic feet, has a single-row floor, walls and roof of 2in o.d. tubes and is separated from the inboard furnace by four rows of 2in o.d. tubes and a bank of seven rows of 1$\frac{1}{4}$in o.d. tubes. The seven-burner inboard furnace has single-row floor and wall tubes of 2in o.d. and a combustion chamber having a volume of 1240 cubic feet. A bank of five loops of 1$\frac{1}{4}$in o.d. tubes forms the superheater, which is shielded by three rows of 2in o.d. tubes. On the far side of the superheater from the inboard furnace is the main bank of twenty-one rows of 1$\frac{1}{4}$in o.d. tubes.

Howden's balanced system of forced draught is installed and each boiler has a 53in single inlet Howden forced draught fan, driven by a 166 h.p. Allen motor, rated to deliver 68,000 cubic feet of air per minute against a pressure of 8in water gauge, and a single inlet induced draught fan, driven by a 230 h.p. Allen motor, capable of dealing with 86,000 cubic feet of gas per minute against a pressure drop of 8·75in water gauge. Clyde hand-operated soot blowers are fitted to the boilers and there are "Mono Simplex" CO_2 recorders and "Igema" water level indicators supplied by James Gordon and Co., Ltd. "Alfloc" boiler feed water chemical treatment plant is installed. For supplying oil fuel to the boilers three Associated British Combustion installations are fitted; they consist of three Stothert and Pitt oil fuel pumps, driven by Allen motors, and three oil fuel heaters, atomisers and registers. Each pump and heater can deal with 14,000 lb of fuel per hour against a pressure of 500 lb per square inch.

Special consideration has been given to the main steam piping system and molybdenum alloy steel has been used for the pipes, flanges, nuts and bolts, the flanges being welded to the pipes.

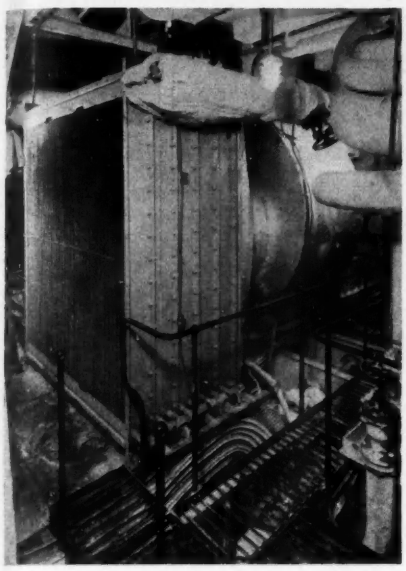
Closed Feed System

Associated with each set of turbines is an underslung Weir regenerative condenser having a cooling surface of 17,500 square feet. It is designed to pass 134,000 lb of steam per hour and maintain a vacuum of 28·85in, with the sea at a temperature of 65 deg. Fah., which corresponds to the maximum s.h.p. of 42,500, or 28in with a sea-water temperature of 86 deg. Fah. at the normal service power of 34,000 s.h.p. The con-

Boiler-room of the "Orsova" showing boiler fronts

denser body is of mild steel with ¾in external diameter by 18 S.W.G. thick cupro-nickel tubes, packed with Crane's flexible metallic packings, and cupro-nickel screwed check pattern ferrules. There are two Allen circulating pumps for each condenser, each pump being driven by a 155 h.p. motor and capable of delivering 12,000 gallons of sea-water per minute against a total head of 26ft or 16,000 gallons per minute against a 20ft head. A closed feed controller is fitted to the condenser and enables any losses in the system to be made up automatically and any excess of water to be discharged automatically to the feed tank.

For each condenser there are two Weir extraction pumps, each having a capacity of



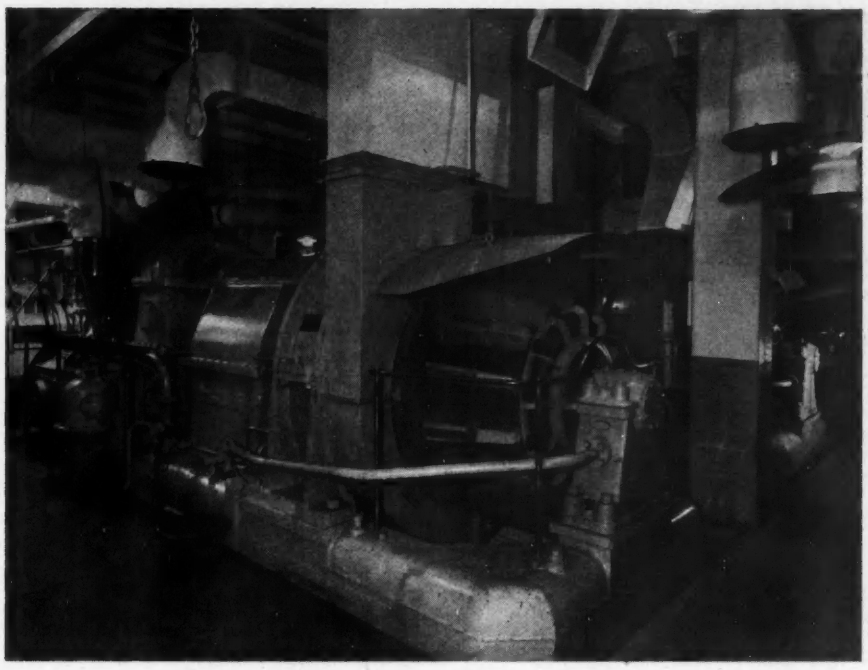
Bled steam air heater mounted on intake side of forced draught fan, showing the vertical arrangement of gilled tube elements

197,000 lb per hour and driven by a 48 h.p. Allen motor. One pump is capable of taking the full load. From each condenser the condensate passes through a three-stage steam jet air ejector and the glands condenser drain cooler of 1000 square feet surface, to the suction inlet of the feed pump. There are three Weir turbine-driven, two-stage, main feed pumps, two working and one standby, each having a maximum capacity of 400,000 lb per hour against a discharge pressure of 630 lb per square inch. In addition there are a harbour turbo-feed pump of 78,000 lb per hour capacity, a three-throw reciprocating boiler feed pump of 20,000 lb per hour capacity against a discharge pressure of 725 lb per square inch and an electrically-driven, two-throw, double-acting feed pump rated at 20 tons per hour against a 50ft head. On the discharge side of the feed pumps the feed water passes through the first and second l.p. feed heaters, the h.p. heater with 650 square feet of surface and, at a temperature of 246 deg. Fah., is discharged through the Weir robot feed regulator to the boilers. Included in the system is a Weir condensate-circulated drain cooler capable of raising 56,050 lb per hour of feed from 110 deg. to 182 deg. Fah., with 35,000 lb per hour of drains at 230 deg. Fah. There is also a sea circulated drain cooler designed to reduce 15,000 lb per hour of drains from 230 deg. to 100 deg. Fah.

To ensure that the feed water, under harbour conditions, is free of oxygen, a Weir Optimum de-aerator plant is supplied consisting of a de-aerating vessel of 60,000 lb per hour capacity, one devaporiser, a supply pump of 56,050–90,000 lb per hour capacity and an extraction pump of 60,000–90,000 lb per hour rating, both pumps being supplied by Drysdale and Co., Ltd., and driven by Allen motors.

Distilling Plant and Auxiliaries

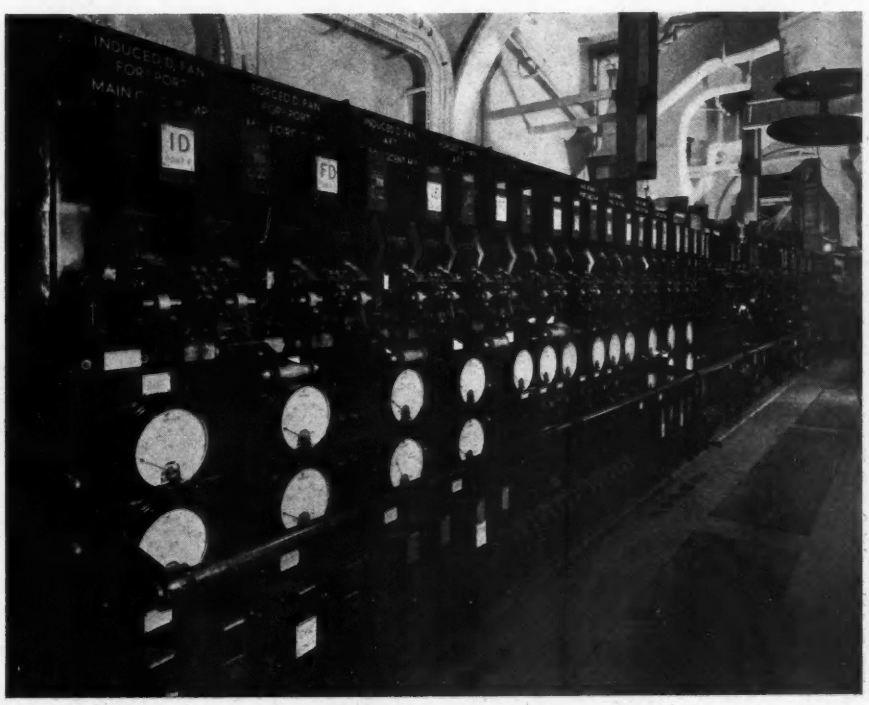
A Weir evaporating and distilling plant is installed in the ship in order to satisfy the boiler and domestic requirements for fresh water



Main generator room with one of the three 1200kW turbo generators in the foreground

without carrying a large quantity of water or buying water at various ports of call. With this arrangement, one of the main feed heaters is used as a distiller for the vapour from the sea-water evaporator, so that most of the heat expended in evaporation is recovered in the boiler feed water. The installation, which has a fresh water output of 300 tons per day, is made up of a single stage for domestic use and a double distillation plant for boiler feed. There are three sea-water evaporators, two working and one standby, each of 1050 square feet surface area, a vapour preheater and a distilled water cooler, each having a surface of 300 square feet, a make-up evaporator capable of producing 75 tons per day, two 50 tons per day distillers for harbour use and a "Belloid" injection plant.

Practically all the auxiliaries are electrically driven, mainly by motors manufactured by W. H. Allen, Sons and Co., Ltd.; this company together with Drysdale and Co., Ltd., and G. and J. Weir, Ltd., supplied most of the pumps. Among these are included a general service and ballast pump capable of delivering 250 tons per hour at 50 lb per square inch or half the quantity at twice the pressure; a bilge and fire pump of 200 tons per hour at 50 lb per square inch and an emergency pump of the same capacity; a bilge pump to deliver 200 tons per hour against a 60ft head and another to pump 60 tons per hour against the same head and a third, a three-throw pump supplied by J. H. Carruthers and Co., Ltd., to deliver 60 tons per hour against a 50ft head. There are also two sanitary pumps, each rated at 220 tons per hour against a head of 120ft; a wing transfer and a bath water pump, each to pump 60 tons per hour against a 90ft head; an oil cooler circulating pump of 2000 gallons per minute capacity, and two oil fuel transfer



Main switchboard at the forward end of the generator room

pumps, each designed to deliver 100 tons per hour against a 70ft head. Forming part of the Drysdale "Pneupress" system are two pumps, each rated at 40 tons per hour against a head of 270ft and a Mather and Platt air compressor to deliver 8 cubic feet per minute at 100 lb per square inch. A Broom and Wade air compressor is installed and supplies 46 cubic feet per minute at 120 lb per square inch.

From the arrangement of the machinery in the engine and boiler-rooms it is evident that the whole has been carefully planned. This has resulted in there being adequate space available for the inspection of the various units and has eased the problem of carrying out of maintenance repairs. The machinery spaces are ventilated by Thermotank axial-flow fans and serving the engine room are four 40in and two 47½in single-stage supply fans and two 30in exhaust fans. Air for the boiler-room is supplied by four 60in axial-flow fans each delivering 45,000 cubic feet per minute against 1½in water gauge.

Electrical Generators

To satisfy the demand for electrical power for auxiliaries, heating, lighting, hotel and other domestic services there are provided three self-contained Allen turbo-generators, each having a full-load output of 1200kW at a pressure of 220V d.c. and an overload capacity of 25 per cent for two hours. The electrical generating plant, which we illustrate, is installed in a separate compartment immediately forward of the boiler room, access being through a vertical sliding watertight door. The turbines, which are designed for a steam pressure of 475 lb.per square inch gauge, and a temperature of 750 deg. Fah., drive the generators through top pinion reduction gearing having a ratio of 7½ : 1 to give a speed reduction from 4500 r.p.m. at the turbine to 600 r.p.m. at the generator. Steam consumption at full load is about 11·27 lb per kilowatt-hour. Each turbine is mounted on its own self-contained surface condenser, which gives a vacuum of 28in with cooling water at 83 deg. Fah. There is an independent condensate extraction pump for each generator set and also a circulating pump of 3325 gallons per minute capacity against a 30ft head. The 220V d.c. generators are force-lubricated, single-pedestal-bearing compound units with drip-proof canopy protection over the commutator, and complete with back-of-board mounting hand-operated shunt field regulator and electrical overspeed trip to work in conjunction with the turbine trip gear. For fluorescent lighting there are fitted in the generator room two Laurence, Scott 75kVA, three-phase, star-connected, 230V alternators, each driven by a 100 h.p. motor. Whipp and Bourne, Ltd., supplied the main switchboard, seen in our illustration, which is about 51ft in length and is arranged for the three generators to feed into a common busbar, while electrical interlocks prevent the paralleling of the generators with the emergency dynamos. Ventilation of the generator flat is effected by two 30in supply fans and two 32½in exhaust fans and, in addition, there are three 32½in fans for direct air exhaust from the generators.

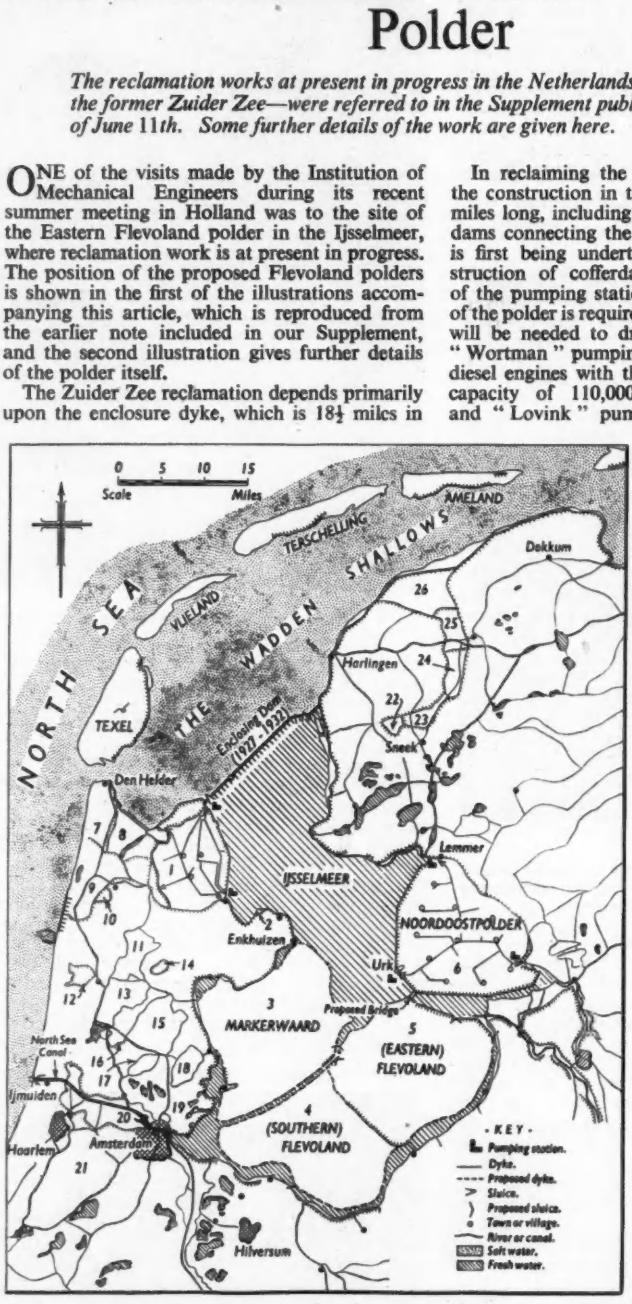
In addition to the main sets, W. H. Allen, Sons and Co., Ltd., has provided two emergency diesel-driven generators, which are installed in a compartment on "D" deck in the forecastle. Each unit consists of a 100kW, 220V d.c. generator driven at 500 r.p.m. by a direct-coupled, four-cylinder, four-stroke diesel engine, and the generators, which are open, drip-proof, single-pedestal-bearing, and compound-wound, are continuously rated and suitable for parallel operation. These sets, which can be used for light loads when the ship is in port, are self contained and include a cooling system consisting of a directly-driven centrifugal circulator and a radiator with fan driven by vee ropes from an extension of the engine crankshaft. The switchboard supplies current to all parts of the ship for emergency lighting, emergency bilge pump and watertight doors, and is interconnected with the main switchboard. A 200Ah nickel iron "Britannia" battery is provided and automatically comes into operation should the main power fail and so supplies the emergency lighting and emergency steering motor until the emergency generators are started or the main generators are restarted.

Reclamation of the Eastern Flevoland Polder

The reclamation works at present in progress in the Netherlands in the Ijsselmeer—the former Zuider Zee—were referred to in the Supplement published with our issue of June 11th. Some further details of the work are given here.

ONE of the visits made by the Institution of Mechanical Engineers during its recent summer meeting in Holland was to the site of the Eastern Flevoland polder in the Ijsselmeer, where reclamation work is at present in progress. The position of the proposed Flevoland polders is shown in the first of the illustrations accompanying this article, which is reproduced from the earlier note included in our Supplement, and the second illustration gives further details of the polder itself.

The Zuider Zee reclamation depends primarily upon the enclosure dyke, which is 18½ miles in length, and was completed in 1932 ; it incorporates ship locks and twenty-five sluices. The complete scheme of reclamation behind the shelter of this dyke envisages a total of 595,000 acres—an increase of 7 per cent in the land area of Holland—leaving an area of 300,000 acres of the Ijsselmeer as a fresh-water lake. The lake level will be controlled, as far as possible, to be about 10in higher in summer than in winter, to supply fresh water for agriculture. The substitution of fresh for salt water in the Zuider Zee was alone considered to be a sufficiently important reason to justify construction of the enclosing dyke, the poisoning of low-lying land by saline ground water being a major problem in the Netherlands.



Reclamation of the Ijssel lake after completion of the enclosing dam :
1. Wieringer-Meerpolder, 50,000 acres, 1927–1930.
2. Trial polder, 100 acres, 1927.
3. Proposed Markerwaard polder, 133,000 acres.
4. Proposed Flevoland (Southern) polder, 110,000 acres.
5. Flevoland (Eastern) polder, 133,000 acres, at present under construction.
6. Noordoost polder, 119,000 acres, 1937–1942.

Reclamation of the Ijssel lake. The legend gives details of the stages of the complete scheme.

In reclaiming the Eastern Flevoland polder, the construction in the Ijsselmeer of a dyke 56 miles long, including breakwaters, harbours and dams connecting the polder with the mainland is first being undertaken. Secondly, the construction of cofferdams surrounding the sites of the pumping stations and the shipping locks of the polder is required. Three pumping stations will be needed to drain the new polder. The "Wortman" pumping station will be driven by diesel engines with three pumps, each having a capacity of 110,000 g.p.m. The "Colijn" and "Lovink" pumping stations will be electrically powered and will contain respectively three and two pumps, each with a capacity of 110,000 to 128,000 g.p.m.

Locks will be built near Lelystad and opposite the Ijssel estuary to give access to the polder canals. The lock near Lelystad will have dimensions of 213ft by 28ft by 10ft, and will accommodate ships up to 600 tons. The lock near the Ijssel estuary will have dimensions of 148ft by 22ft by 8·5ft for ships of 250 to 300 tons. Harbours have been designed near the Ijssel estuary, Harderwijk and Lelystad, that near Lelystad being the most important. To avoid serious disturbance of the hydrological regime of the mainland a border lake, called Veluwelake, with a width from 1000ft to 8200ft, will be left between the mainland and the new polder. At three places, near Harderwijk, Elburg and west of Kampen, there will be approaches to the polder. The Veluwelake will be separated from the Ijsselmeer, by dams in which locks and sluices will be constructed.

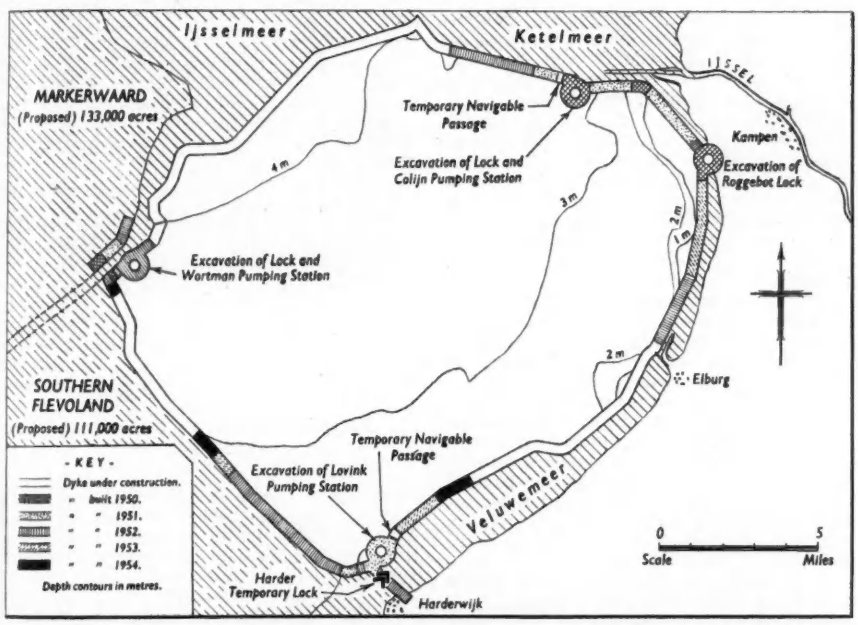
Dyke construction was started at four places—in the middle of the former Zuiderzee, 14 miles east of the village of Volendam, near the Ijssel estuary, near the mainland next to Kampen and near Harderwijk. A start was made this spring along the future Veluwelake between Harderwijk and Elburg. Almost half of the dyke has now been constructed.

Lelystad, the future capital of all the polders in the basin of the Ijsselmeer, will be situated along a canal with a width of 1300ft connecting the Ijsselmeer with the lake and Amsterdam, and named "Oostvaardersdiep." A population of 30,000 inhabitants is envisaged for the town, or perhaps double that number if industrial development is undertaken. A second town has been planned having 3000 to 5000 inhabitants, together with about ten smaller villages of 1000 to 1500 inhabitants.

The sea bottom of the future polder has a regular slope from 6ft below N.A.P. near the coast,

down to 13ft below N.A.P. in the central part of the former Zuiderzee. The polder will be divided into two sections, the levels of which will be 17ft and 20ft below N.A.P., and it will be intersected by canals, utilised both for drainage and for shipping. About 45 miles of primary roads, 140 miles of secondary and tertiary roads, and about 170 miles of local roads have been planned, and the polder will be connected with the north-east polder by a bridge. The cost of the hydraulic works of Eastern Flevoland has been estimated at 290 million guilders (10 guilders =£1), and the agricultural works at 350 million guilders. The price per acre will be about 4900 guilders.

The dykes of the north-east polder are being constructed by similar methods to those used for the earlier Zuider Zee works. Boulder clay is dredged in the Ijsselmeer near Urk and Vollenhove and transported by ship to the works. Sand is won from the Ijsselmeer near the work by suction dredgers. At the site of a proposed dyke, the soft layers of the sea bottom have first to be dredged and replaced by sand ; on this foundation two dams of boulder clay are dumped along each side of the line of the dyke, and sand is pumped between them in much the same manner as was described for the sea defence dykes in South-Western Holland in our previous article. The sand is protected with a layer of boulder clay. The slopes below water level are protected by mattresses of brushwood, sunk and



Construction of the Eastern Flevoland polder in the Ijsselmeer. The polder has an area of 133,000 acres and a circumference of 56 miles

covered with riprap. The higher slopes of the dyke are covered with stone pitching. According to the situation of the dyke, lighter or heavier materials are used, such as bricks, concrete, basalt, &c. Before the stone is laid, the slope of the dyke is covered with mats of rice straw, imported from Korea, on top of which a layer of broken bricks is applied. The surface of the dyke is, as far as it is not protected by stone, covered with a layer of clay, upon which grass is sown. The engineers in charge are experimenting with asphalt slabs, made on and emplaced from a ship specially constructed for this purpose, to replace the brushwood mattresses. The body of the dyke above water is partly protected by bituminised sand. The covering of the dykes along the Veluwelake will consist mainly of bitumenised sand and a turfing of grass on a dressing of clay.

It is expected that pumping of the polder will be started in 1955, and will take about eight months ; after this, reclamation and cultivation of the polder will commence. It is thought that the polder will be one of the most fertile in the Netherlands. The entire work is in the hands of the Board of the Zuiderzeewerken, which is a department of the Rijkswaterstaat.

Machining Hard Metals with Electric Sparks

The process of cutting with an electric spark is exemplified in the " Sparcatron " equipment described and illustrated here. This method offers a means of working metals which are too hard to be readily machined by edge tools or ground by abrasive wheels. Up to the present the development of the process has been concentrated on the production of holes and forms where the component can be held stationary but the process has wider potential applications.

THE " Sparcatron " process makes use of the energy in an electric spark to blast away particles of metal as the arc strikes the workpiece. To make such a process suitable for carrying out accurate machining operations the electric sparks are applied to the workpiece and controlled by equipment which has been developed and manufactured by Impregnated Diamond Products, Ltd., under licence from Sparcatron, Ltd. This equipment is marketed in Great Britain and Northern Ireland by Burton, Griffiths and Co., Ltd., Mackadown Lane, Birmingham, 33.

The principle of the " Sparcatron " process is that an electric spark is caused by the sudden breakdown of a dielectric separating two electrodes : if the workpiece to be machined is made to be one electrode and another electrode of opposite polarity is brought to within the breakdown point of the dielectric separating them, the ensuing spark will remove a minute particle of the workpiece. For a spark to occur at all, a finite gap must always exist between the two electrodes. With any dielectric under a given set of conditions, the occurrence of a spark discharge depends on the size of the gap and the potential difference across the electrodes. Another elementary factor upon which the " Sparcatron " process relies is that an electric spark will always bridge the shortest point of the gap between the electrodes. Because of this fact, whatever cross section or contour the electrode may have, the removal of metal in the workpiece will follow the pattern of the electrode exactly. Although the original spark discharge may take place from any point on the face of the electrode, as soon as this discharge has occurred, material at that point on the workpiece is removed and the gap there becomes larger than elsewhere ; sparking must therefore take place from another point on the electrode and so on until the complete surface of the electrode is covered. At this stage a minute thickness of material will have been removed from the workpiece, following the exact shape of the electrode. Theoretically, sparking will then cease because the overall gap between the electrode and the workpiece is greater than that required for a spark discharge under the prevailing conditions. However, if a practical means of maintaining the gap at the optimum value can be applied, and the generation of spark discharges made repetitive and continuous, metal removal will continue indefinitely or until the hole is fully pierced or the desired sunken contour is achieved.

We have established that the base profile and surface contour of the electrode is exactly the

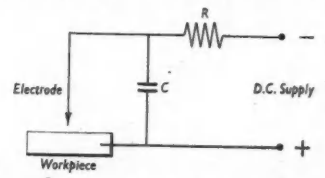


Fig. 1—The basic circuit of the " Sparcatron " process

same as the aperture to be cut. However, the fact that a gap, however small, exists between the electrode and workpiece, means that the electrode must be smaller on all dimensions, by an amount equal to the spark gap, for a given finished size. Also, for a given voltage difference between the electrode and the workpiece and for a given dielectric separating them, the spark gap must be maintained at the correct " breakdown " distance. Provision must also be made for generating properly spaced spark discharges in a continuous sequence.

Here three practical factors must be considered. First, the length and intensity of the individual spark impulses and the length of the intervals between them must be carefully controlled to prevent the formation of a continuous arc.

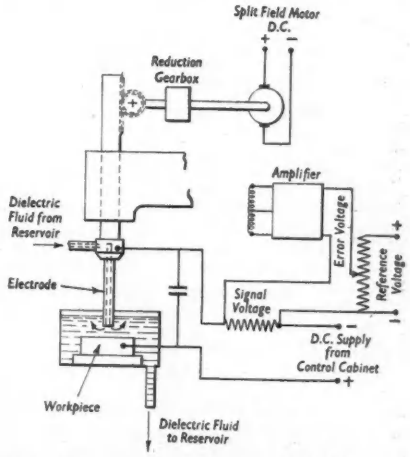


Fig. 2—The control circuit used to maintain the correct relationship between the electrode and workpiece

Secondly, provision must be made to control the intensity of the sparking effect over a wide range because the surface quality obtained with this process (as in others) depends upon the cutting rate ; the higher the surface quality required the slower must be the cutting rate. Thirdly, the point of spark application must be kept under precise control, because the accuracy of the resulting cavity is related to the spark gap. For example, the resulting diameter of a

plain circular hole will be that of the electrode plus the radial clearance which constitutes the spark gap. As the accuracy of machining is so closely related to the spark gap and is therefore bound up with the electrical characteristics of the system, it follows that the spark gap should be kept as small as compatible with operational requirements, including that of cutting speed.

The "Sparcatron" Process

A simple relaxation circuit, shown in Fig. 1, is the basic circuit used in the "Sparcatron" equipment for the generation of the required train of spark discharges. The energy for the spark discharge is derived from condenser *C*, which is charged from a d.c. source produced by the circuits within the "Sparcatron" cabinet. At the start of the cycle the voltage across the condenser and the operating gap is initially zero, but it rises exponentially until it balances the supply voltage. However, the spark gap is such that the breakdown voltage of the dielectric medium separating the electrodes is reached just

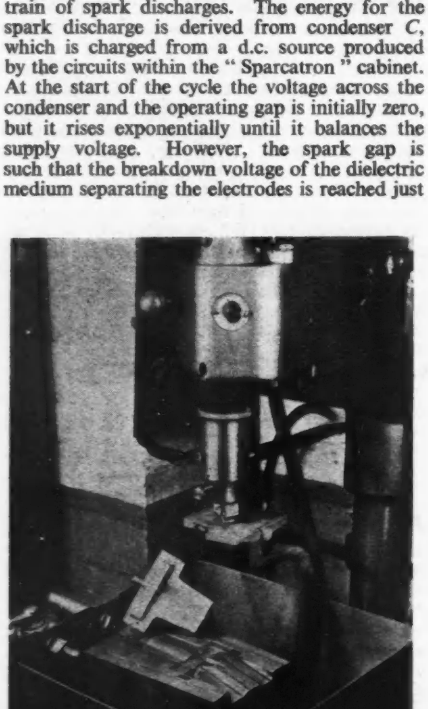


Fig. 3—Sinking one half of a forging die in hardened die steel. A spare brass electrode rests face up on the die to show its shape

before the condenser is fully charged. A spark occurs and the condenser is rapidly discharged across the gap. The discharge is therefore damped and an arc cannot develop across the gap; the succeeding spark will occur only when the condenser is recharged to the breakdown value again. This cycle of events is repeated automatically, sparks recurring one after the other in rapid sequence.

The amount of energy released in the spark gap when the condenser discharges is directly proportional to the capacitance of the condenser and to the square of the applied voltage. There are, therefore, two means of controlling the intensity of the sparks and hence the rate of metal removal; by varying the voltage and by varying the capacitance of the condenser. "Sparcatron" equipment provides two outputs —110V, 10A, or 25V, 100A, and a bank of condensers, separately switched, give a range of combinations from 1mfd to 612mfd. In Fig. 1 the control and protection equipment, metering and switching are omitted, for simplicity.

Control of the electrode, so that the correct spark gap is consistently maintained, is carried out by a sensitive servo mechanism. The gap required when operating on 110V is approximately 0·0003in to 0·001in. To maintain such fine control the servo mechanism is coupled electronically to the spark discharge circuit, as shown in Fig. 2, and functions automatically in relation to the discharge current. A signal voltage proportional to the discharge current is fed from a resistor in series with the electrode and "compared" with a reference voltage. The reference voltage is adjusted so that, with

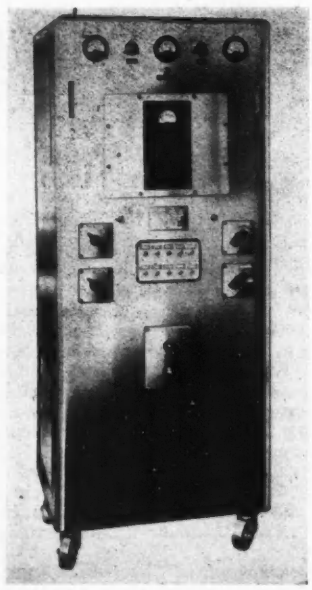


Fig. 4—The "Sparcatron" converter unit and control cabinet

the electrode correctly positioned, the two voltages are equal and the effective signal voltage is zero. If the electrode deviates from this position a positive or negative "error" signal is fed into the amplifier, the output of which energises the d.c. servo motor. The motor is of the split field type and its direction of rotation depends on the particular side of the field energised, which in turn, depends on the polarity of the error signal. The motor shaft is coupled to a reduction gear which drives a pinion engaged with a rack on the electrode holder. Thus, the electrode is raised or lowered, automatically, in relation to the discharge current and the precise gap between the electrode and the workpiece is maintained. Anti-hunting circuits are incorporated in the electrode drive.

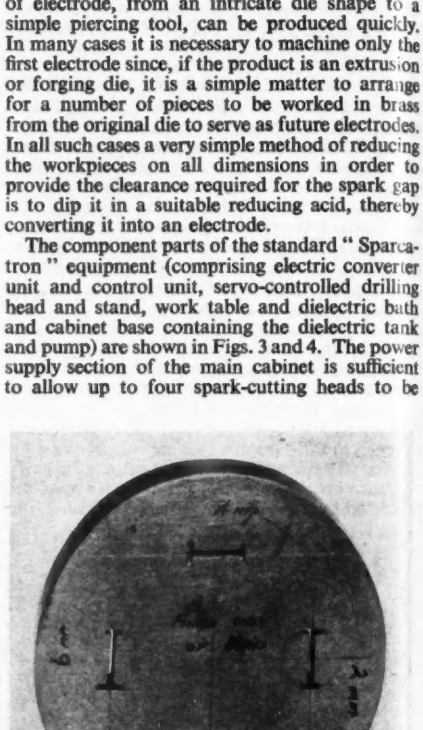
Although spark machining may, in theory, be carried out with electrode and workpiece separated only by air, in practice a liquid dielectric is used, principally for its cooling effect, but also for certain electrical properties. Generally, the liquid employed is ordinary paraffin, although specially prepared liquids may be used. Although paraffin is inflammable, no ignition of the liquid can take place because the cutting point is fully immersed and insufficient oxygen is present to support combustion. The "Sparcatron" equipment includes a circulating system whereby the dielectric paraffin is pumped, from a settling tank in the cabinet base of the machine, into a dielectric bath surrounding the work table, and back to the tank. This method improves the cooling effect and removes the fine sludge produced by the process, causing it to

Fig. 5—"Sparcatron" auxiliary unit. Three of these units may be used with three extra spark-cutting heads in conjunction with a main control unit, making a total of four spark machining positions

settle at the bottom of the tank, from where it can be removed periodically.

The electrode may be fashioned from almost any soft material which forms a good electrical conductor, brass is generally recommended because it is easily worked and almost any form of electrode, from an intricate die shape to a simple piercing tool, can be produced quickly. In many cases it is necessary to machine only the first electrode since, if the product is an extrusion or forging die, it is a simple matter to arrange for a number of pieces to be worked in brass from the original die to serve as future electrodes. In all such cases a very simple method of reducing the workpieces on all dimensions in order to provide the clearance required for the spark gap is to dip it in a suitable reducing acid, thereby converting it into an electrode.

The component parts of the standard "Sparcatron" equipment (comprising electric converter unit and control unit, servo-controlled drilling head and stand, work table and dielectric bath and cabinet base containing the dielectric tank and pump) are shown in Figs. 3 and 4. The power supply section of the main cabinet is sufficient to allow up to four spark-cutting heads to be



Time taken for each slot	55 mins.
Power used	65 watts
Capacity	6 microfarads

Fig. 6—Typical extrusion die, thickness 4in. Four slots equally spaced

operated. Separate auxiliary control units (Fig. 5), comprising servo-control amplifier and condenser bank for each additional head, are being manufactured by Impregnated Diamond Products, Ltd. These small auxiliary units enable other heads to be added at much less cost than the original unit, up to a total of four.

The surface produced by spark-cutting has a non-directional finish (unlike the grooved finish of mechanical grinding and turning) and has special oil retention properties. Furthermore, the changeover from rough to finish machining involves merely the switching out of condensers and can be carried out instantaneously without interrupting the cutting. For example, suitably "stepped" or tapered electrodes enable holes to be rough pierced at a fast rate (using a high condenser value) during the first part of the electrode and then finished machined for the latter part of the electrode simply by switching to a low condenser value.

At the present stage of development the process is mainly used for the production of holes and forms where the workpiece can be held stationary. It is used, for example, in the making and opening of wire and extrusion dies (Fig. 6), blanking and forging dies (Fig. 3), and the machining of form tool shapes. Among the developments projected is that of applying the "Sparcatron" head to a thread cutting machine for the production of threads in tungsten carbide.

The process can be applied to the grinding of carbide tool tips where the absence of friction heat eliminates surface stresses and microcracks. It is also possible to completely finish-harden parts and then finally machine by spark-cutting without fear of distortion.

Shell Moulding Equipment

An integrated range of shell moulding machines and equipment which has been developed by the Polygram Casting Company, Ltd., now includes machines taking pattern plates up to 22in by 24in, automatic shell core making machines, mould closing machines, &c.

LAST week the Polygram Casting Company, Ltd., of Power Road, London, W.4, gave a series of demonstrations at its works to introduce a range of new shell moulding equipment which it has developed to widen the field of application and speed production with the shell moulding technique. The equipment shown in operation included a new two-station shell mould making machine, two forms of automatic and one hand-operated shell core making machines, a shell mould closing machine, a resin-sand mixing machine and a sand reclaiming unit.

The new shell mould making machine, which is illustrated in Fig. 1, is a two-station, semi-automatic machine at present made in two sizes to accommodate pattern plates from 16in by 12in to 20in by 14in, and 14in by 18in to 22in by 24in. In this machine the dump box is situated in the rigid frame structure between the two ovens. The pattern plates on each side are supported on a pneumatically operated rollover system of pivoted levers which swing the plates over and deposit them on to the dump box. Suitable counterbalancing means are provided to prevent undue shock when the pattern plate contacts the dump box. The plate is automatically clamped on the box, which is reversed by rotation of a handwheel. When, at the end of the deposition period, the box is restored to its upright position, the plate is picked up by the transfer levers and carried over into the appropriate curing oven. In these ovens electric heating elements are arranged in the bottom and in the hinged top cover of the chamber which is swung over by hand.

At the end of the curing period the cover is raised and the shell mould is ejected off the pattern plate whilst it is still in the oven. The ejector pins are not spring loaded as is usual in this type of machine but are carried on a plate below the pattern plate frame. Whilst the pattern frame is out of the oven for the deposition operation the ejector pin plate is held out by a hinged wedge which automatically comes into effect when the frame swings out of the oven. As the pattern plate is swung back into the oven the wedge is automatically disengaged so that at the conclusion of curing the ejector plate is free to be lifted for its pins to release the mould by air-operated plungers situated in the lower chamber of the oven. This means of ejector pin support and operation eliminates possible danger of the pins dropping forward as the pattern plate is inverted. It will be appreciated that whilst one pattern plate with its mould is in one curing oven the pattern plate of the other oven is inverted, so that a continuous cycle can be maintained by alternate operation of the two units.

The shell core making machines introduced by this firm are the outcome of some six years' development and research. In this work efforts were directed to designing machines which would be suitable for making a wide range of both complex and simple cores. The aim was to make such cores hollow wherever possible to achieve high permeability and reduce material costs whilst maintaining high strength, delineation and finish. As a result of this work there have now been introduced two fully automatic machines and a simple hand-operated machine.

One of the automatic core making machines is that shown in Fig. 2, which is a three station machine. As can be seen, the machine consists essentially of a cabinet base carrying three core blowing tables and a column on which is pivoted a combined blowing and evacuating head and hopper. The hopper has a capacity of 60 lb to 70 lb of material and two of the three tables are designed to accommodate core boxes of normal dimensions, whilst the third table can take boxes up to 24in long. Each table is fitted with adjustable location pieces for the core boxes, and most conventional core boxes can be used on the machine provided they are made of suitable metal. A separate evacuating equipment and curing oven are used in conjunction with the machine.

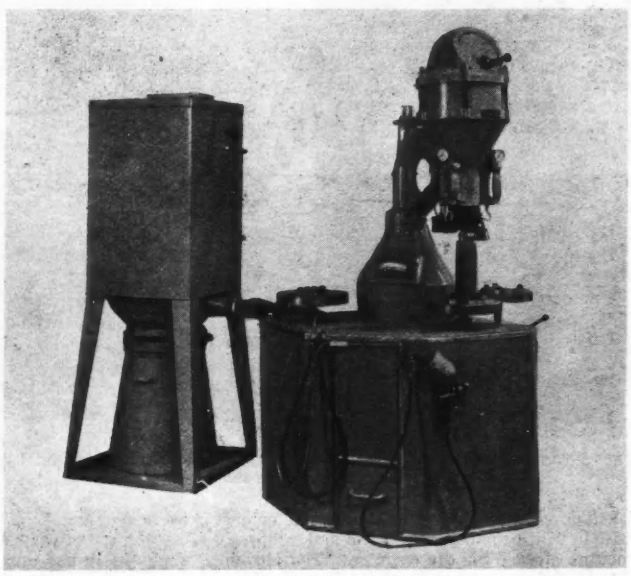


Fig. 2—Three-station automatic shell core making machine with swinging blowing head and hopper

In the cycle of operations a previously heated core box treated with stripping solution is held in position on the work table and the blowing head swung into position over it. The blowing nozzle is then placed over the core box mouth and the sand-resin mixture is blown in by means of compressed air. With the box full of the mixture, the blower is switched off and sufficient time is allowed for the formation of a shell of the required thickness. At the end of this period the head is swung a short distance sideways to bring the mouth of an evacuation system over the core box mouth. The vacuum is then brought into effect and the surplus sand-resin mixture is drawn out to leave the shell in the box, which is then placed in the curing oven. While this core is curing a second core is made in a similar manner on the other table which is adjusted in accordance with the box height, and the cycle is repeated on the third table. Thus, if required, three different sizes of core boxes can be handled on the same machine.

The second machine, of similar design, is fully automatic and is arranged for long production runs. As can be seen from Fig. 3, it has two stations each of which holds a core box. The core boxes used on the machine are split and are opened and closed automatically by pneumatic means. Electric heating elements in the core box clamps are used for curing the shell cores on this machine. The process of filling and evacuating the core boxes is similar to that of the machine described above except that the cores are cured before removal from the boxes. It is designed to take core boxes up to 9in by 6in by 6in. Both of these core making machines have built-in pyrometers, a spray gun for applying the stripping solution and a cleaning air blast.

For use in jobbing foundries where a wide variety of core boxes are in use the straightforward blowing machine shown in Fig. 4 has

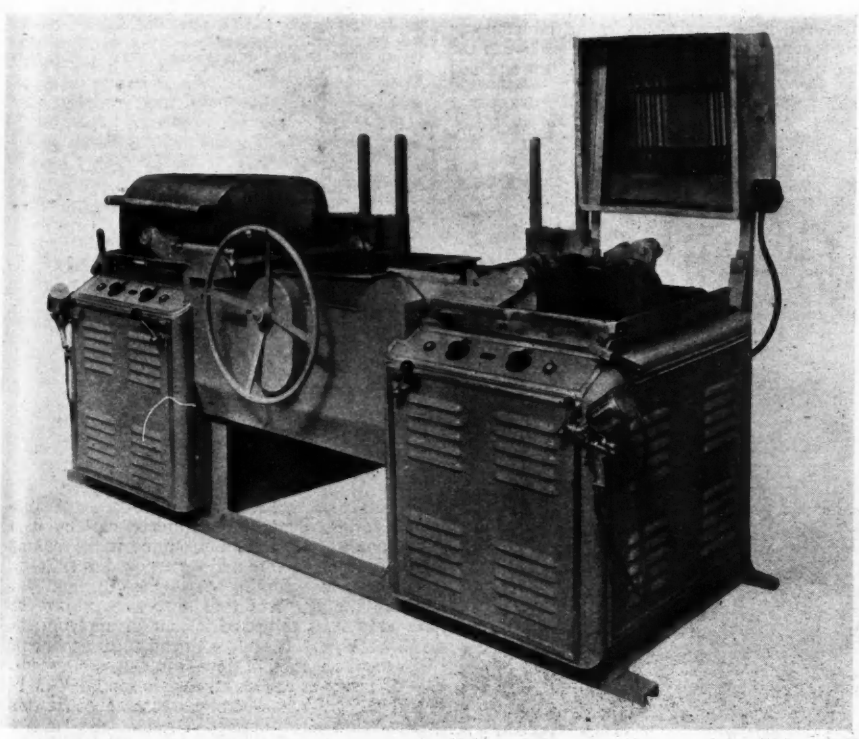


Fig. 1—Two-station semi-automatic shell mould making machine with central core box and electrically heated curing ovens

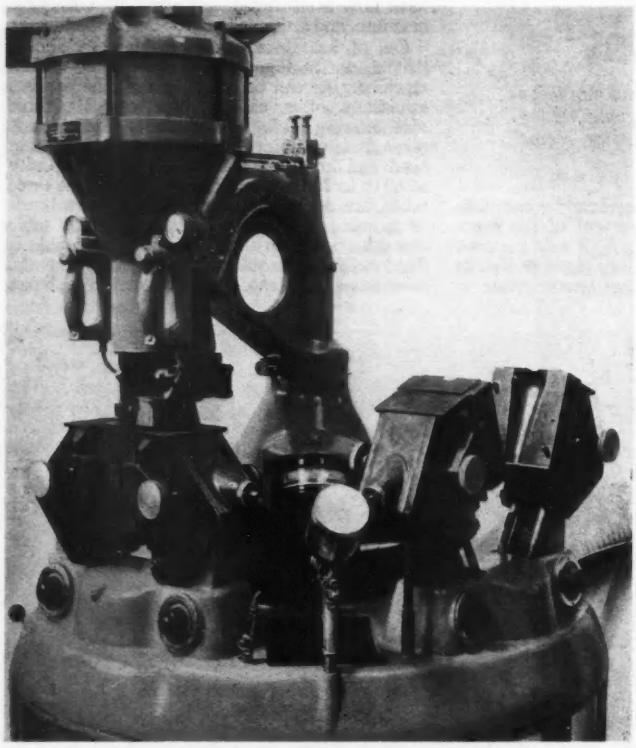


Fig. 3—Automatic two-station shell core making machine with electrically heated core boxes for curing the moulds

been developed. This machine has a cabinet base in which the blowing system and sand-resin mixture storage bin are enclosed. The blowing nozzle of the machine projects up from a grillage and the preheated core box is inverted and placed on the nozzle, where it is held firmly in position by a quick-action overhead clamping arm. Depression of a pedal admits a blast of resin-sand mixture to fill the box. When the inverting period has been completed the box is removed from the nozzle and the surplus material is shaken out over the grid through which it drops into the bin below. Periodic operation of a lever returns the material in the bin to the adjacent blowing reservoir in the cabinet. The mould boxes are placed in a separate oven for the curing process. A pressure control valve can be adjusted to give the required blowing pressure.

A particular problem in shell moulding is the use of a satisfactory and simple method of mould closing and the firm points out that the general practice of using clips, bolts, &c., does not always make it possible to exert a uniform pressure over the whole surface of a mould. To overcome this difficulty the mould closer illustrated in Fig. 5 has been developed, and it is used in conjunction with an adhesive compound.

The closer consists essentially of two rubber diaphragms, one fixed and the other carried on a hinged frame. When using the machine the upper half of the shell mould is heated in the oven at the side of the machine, whilst the mating faces of the lower half are coated with the adhesive. The cold lower half is then placed on the fixed diaphragm and the heated upper half placed on top, pin inserts being used to give true registration.

The hinged diaphragm is then swung down over the mould and when the air between the diaphragms is exhausted a uniform pressure of about 14 lb per square inch is exerted on both sides of the mould. This pressure is maintained a sufficient time for the adhesive to set and when the mould is removed the two half-shells are firmly stuck together. The makers state that with this machine up to sixty moulds an hour can be closed.

As a hot setting adhesive is used the temperature to which the upper half of a shell mould is heated for closing is critical. For this reason the mould heating oven to be seen on the left of the closing machine in our illustration was developed. This oven is designed to maintain the temperature to within ± 10 deg. Cent., irrespective of the time a shell remains in it. The shells are placed on the arms of a moving rack in the oven. Each time the oven door is opened the rack is automatically rotated one stage to carry the cold shell into the chamber and bring a heated shell to the unloading position. A thermostat lock prevents the oven door being opened until the temperature within the chamber is within its preset limits.

The firm's recently introduced ancillary equipment for shell moulding includes a simple mixer for the sand and binding material used and a sand reclaiming oven. The mixer consists of a drum fitted with agitator arms and into which the mixture is deposited. The drum is then laid on rubber-faced rollers mounted in pairs on spaced shafts which are driven by a small motor to rotate the drum. Whilst the drum is rotated the resin and sand are thoroughly mixed by the action of the agitator arms. Two drums, each of 1 cwt capacity, are supplied with the machine so that mixing can be carried out in one whilst the other is being unloaded and recharged.

The reclaimer for sand is essentially a cylindrical stove in which the resin still remaining in shell moulds after the castings have been removed is burnt out of the sand. To start the reclaimer a 12in depth of broken moulds in its lower part is ignited by means of a gas torch. With these moulds burning the firing chamber is filled up and as the resin burns out of the moulds the sand trickles down and out through a hole at the foot of the chamber. It is stated that this equipment reclaims usable sand at a rate of 1 cwt to 1½ cwt per hour.

WATER TRACTOR DEMONSTRATION.—This week, by the courtesy of William Cory and Son, Ltd., a demonstration of the Voith water tractor, which has Voith-Schneider propulsion, was arranged by Captain E. C. Goldsworthy at the Victoria Docks. This water tractor is built by J. M. Voith G.m.b.H. Engineering Works, Heidenheim (Brenz), Germany, and is available in two standard forms, namely, "Bee" and "Hornet." The "Bee" water tractor has one Voith-Schneider propeller driven by a single diesel engine of up to 150 b.h.p., while the "Hornet" has two propellers and two engines. The demonstration vessel was the "Bee" unit, which has a length of 33ft by a breadth of 9ft 10in, a draught of 4ft 7in, and a displacement of about 12 tons, and is powered by a six-cylinder Deutz diesel engine, which drives the propeller through bevel gearing to give a speed reduction of 10 to 1. The engine is mounted aft and the propeller is located slightly forward of 'midships, while the hull, which is of chine form, has lines designed to give a good flow of water to the propeller, and to ensure that the forward suction component in front of the propeller adds to the thrust. Control of the tug is simple, there being a single lever to control the ahead or astern movement and a wheel to control directly the propeller blade angle to give athwartship thrust either to port or starboard, while a third lever governs the engine revolutions.

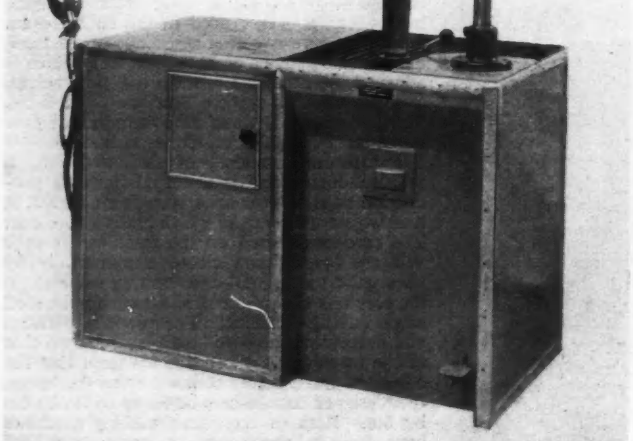


Fig. 4—Manually operated core blowing machine with core box in position on the blowing nozzle for the resin-sand mixture

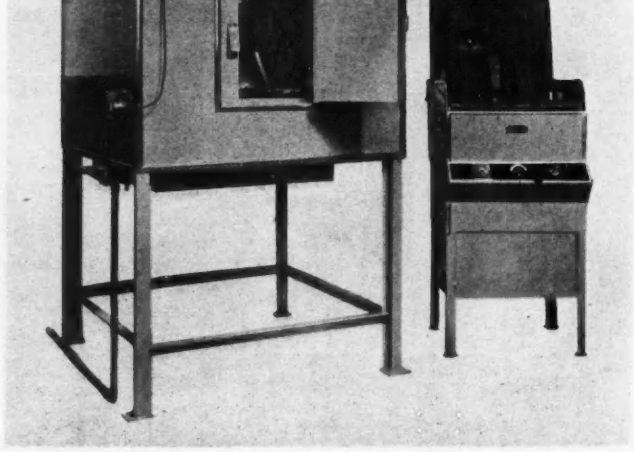


Fig. 5—Shell mould closer with the upper diaphragm raised. The heating oven for the upper half of the shell moulds is shown on the left of the closer with its door open

Royal Show at Windsor

No. I

ON Tuesday next, July 6th, the Royal Agricultural Society's annual show will open in Windsor Great Park, by the gracious permission of Her Majesty the Queen, who is the President of the Society this year. During the 115 years of its life the Royal Agricultural Society has held three shows previously at Windsor. The first of them was in 1851, when the livestock entries, totalling 988, attracted considerable attention, but when the implement section was omitted on account of the Great Exhibition which was running in London that year. The second Royal Show at Windsor was in June, 1889, the year of the Society's golden jubilee. The late Queen Victoria accepted office as president, and during the seven days of the show the attendance totalled 155,707. The site for that show occupied 127 acres.

At the 1889 show implements and machinery were much in evidence, the number of individual items exhibited being recorded as 7446, displayed on 553 stands. In our pages, however, we commented that "there were very few novelties in any class," although we hastened to add that the engineering firms represented were so busy that they were unable to execute without some delay "the orders almost forced upon them by their clients from all parts of the world."

The last time the Royal Show was held at Windsor was in July, 1939, when the Royal Agricultural Society celebrated its centenary. The late King George VI was the president. The show ground occupied 126 acres and the livestock entries broke all previous records. The machinery exhibits, too, were numerous and constituted the last major display of mechanised farming equipment that it was possible to arrange until after the second world war. In addition, as was to be expected at the centenary show, there were several exhibits which demonstrated the development of farm implements and machinery during the preceding 100 years, a period in which the application of steam power and latterly the internal combustion engine steadily reduced the usage of animal power on the land. The centenary show was open for five days, during which time it was visited by 118,036 people.

Next week's show at Windsor will retain many of those characteristics traditional of the "Royal." But it will also emphasise again the importance of mechanisation in the business of farming. The area occupied by the show is no less than 151 acres, and this year there will be 685 trade stands, taking up 1,250,000 square feet of space. An item of particular interest in the show programme is an exhibition of historic horse-drawn carriages, many of which will take part in a parade in the Grand Ring on each day of the show.

In the machinery section, fifteen new implements have been accepted for adjudication for the Royal Agricultural Society's silver medals and six implements deferred from last year are to be considered again. The judging is to be undertaken by Mr. A. Herbert Carter, Mr. Leslie Langmead and Mr. Rex Paterson. In this article we begin a description of some of the machinery and implements which will be shown on the trade stands.

One of the oldest exhibitors at the Royal Show is Ransomes, Sims and Jefferies, Ltd., Orwell Works, Ipswich. Many of this firm's products will again be shown on two stands, one of them devoted to agricultural machinery and the other to lawn mowers. The agricultural machinery will include the "Vibro-Hoe," which is to be adjudicated as a new implement for the Society's silver medal. The prototype was described in our issue of December 19, 1952. Another new machine, which will be exhibited for the first time, is the "Cropguard Junior" sprayer, illustrated in Fig. 1. The sprayer, which is assembled on a triangulated steel frame, is adjustable to all tractors equipped with three-point linkage. The spray boom is supported by three pressed steel sections, which are hinged to fold horizontally for transport, a safety release allowing each outer section to swing clear of obstructions and then return automatically to the spraying position. The height of the boom can be adjusted between 18in and 26in from the ground, and the normal spraying width is 17ft. Extensions to the boom are available, however, to permit a spraying width of 20ft. The ceramic-tipped spray jets are shaped to indicate clearly the line of spray, and are available in three sizes to give applications between 5 and 20 gallons per acre with the 17ft boom and from 5 to 18 gallons per acre with the extended 20ft boom. Each jet is fitted with a non-choking trap to prevent accumulated sludge from reaching the orifice. The spray control valve, which is operated by a single lever, incorporates a "suck back" device to eliminate any drip from the jets when the lever is in the "off" position. The seam welded 30-gallon cylindrical tank is independently seated on the suspension frame, and is provided with a hydro-jet agitator. A roller vane pump, which is driven directly from the tractor power take-off shaft by a keyed sleeve and check chain, has a free output of 275 gallons per hour.

At the centenary show at Windsor in 1939, Ransomes, Sims and Jefferies, Ltd., provided an interesting historical display of ploughs. This year, the firm's latest designs of tractor-trailed and mounted ploughs will be seen. A very recent addition is the four-furrow mounted plough, illustrated in Fig. 2, which has been produced in co-operation with Ford Motor Company, Ltd., Dagenham, Essex. The frame of this plough is built up of high carbon steel bars, and the steel legs which carry the plough bodies can be bolted to the inner or outer sides of these bars, thus permitting speedy adjustment for either 10in or 12in ploughing width. The plough is equipped with lightly-constructed semi-digger bodies, a "dropper" being fitted to No. 3 body to prevent damage to the share points when the plough is

Fig. 1—"Cropguard Junior" sprayer, with normal spraying width of 17ft. The tank capacity is 30 gallons

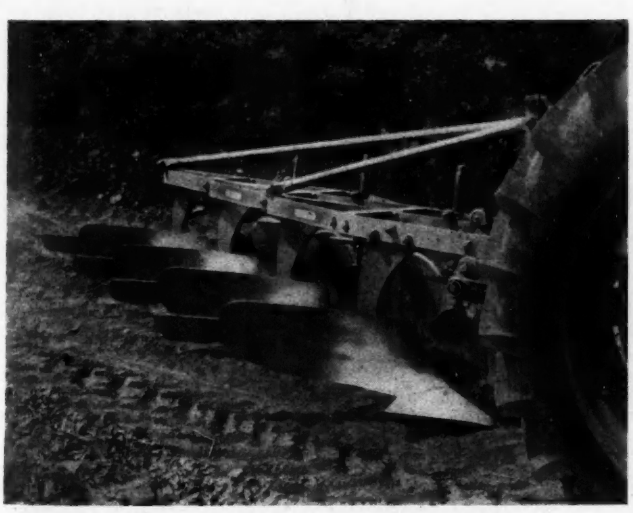


Fig. 2—Four-furrow mounted plough with semi-digging bodies, for use with "Major" tractor with pre-set linkage control

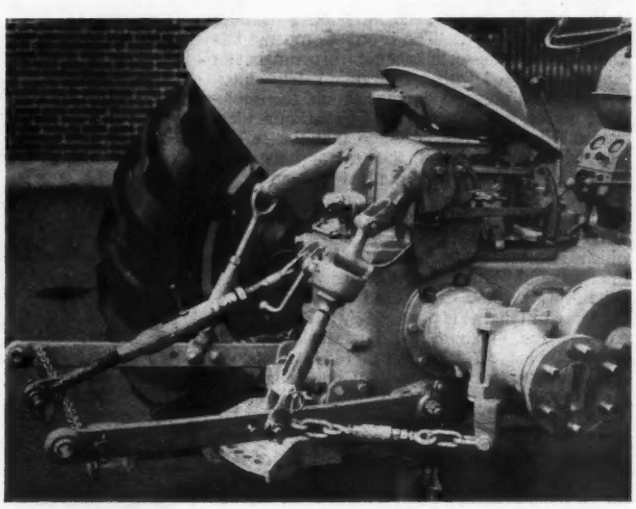


Fig. 3—Pre-set linkage control and extending top link on the Fordson "Major" tractor

lowered. This plough has no depth wheel, the only control being a screw by which the operator can adjust the front furrow width from the tractor seat.

The design of this four-furrow plough has followed the introduction by the Ford Motor Company, Ltd., of a pre-set linkage control for the "Major" tractor. Tractors fitted with this linkage control arrangement, which is shown in Fig. 3, will be exhibited on the Ford stand. The mechanism, which is used in conjunction with the Fordson standard hydraulic lift equipment, to this tractor, a new hydraulic system has been devised. The drive is taken directly from the engine timing gears and is in no way affected by the tractor clutch, so that implement lowering and lifting can be accomplished quite independently whether the clutch is engaged or disengaged. The basic hydraulic attachment consists of an engine-driven pump, fluid reservoir, pipelines and hydraulic control valve. To this equipment a three-point linkage and double-acting 3in cylinder, with hydraulic drawbar control can be attached. The makers say that the chief point about this linkage operation is that both the lifting and lowering motions are powered as the cylinder is double acting. To utilise this advantage fully and to eliminate the risk of setting down a heavy implement too quickly, the valve control knob has a variety of settings and moves both vertically and horizontally. In the vertical range there are the four essential positions of raise, lower, hold and float. By moving the lever a little forward and repeating the motion, the lowering is retarded and it becomes progressively slower as the lever is advanced, until no effect at all is produced. When past the "dead spot," a new vertical range is entered which can be used to operate additional remotely controlled or slave cylinders, for which tappings are provided on the control housing. The tractor is provided with a swinging drawbar which is attached well forward of the rear axle, the height of which above the ground can be varied between 7in and 20in when operated with the three-point linkage. Other attachments to the tractor are a belt pulley, giving a belt speed of 2588ft per minute at rated engine speed, and a power take-off shaft, the speed of which is 537 r.p.m.

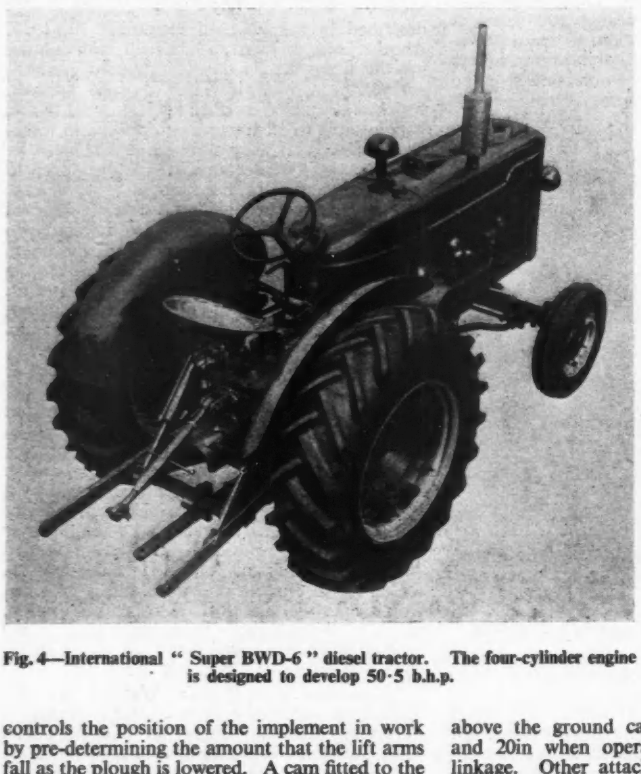


Fig. 4—International "Super BWD-6" diesel tractor. The four-cylinder engine is designed to develop 50·5 b.h.p.

controls the position of the implement in work by pre-determining the amount that the lift arms fall as the plough is lowered. A cam fitted to the offside lift arm and an additional control lever are used to select working depth. On this lever there is pivoted a rocker arm which actuates the hydraulic lift lever when the cam makes contact with it. In operation, the depth of work is selected and the control lever locked in position, the hydraulic lift lever then being pushed to the "down" position. Oil is exhausted from the ram cylinder and the lift arms continue to fall until the cam comes into contact with the rocker arm, which pivots and moves the lift lever to the "neutral" position. The implement is thus held at a constant depth by a column of oil in the ram cylinder. To overcome any small irregularities in the ground contour, the mechanism includes a slotted top link. The Ford Company has stated that this pre-set linkage control arrangement can also be used with a hydraulic safety clutch release which prevents damage should the implement strike an obstruction. From our illustration (Fig. 3) it will be noted that the offside rear wheel and wing of the tractor have been removed to show this control system more clearly.

Among the new tractors to be shown at Windsor next week is the "Super BWD-6," which is now being put into production by International Harvester Company of Great Britain, Ltd., 259, City Road, London, E.C.1. This tractor (Fig. 4) is powered by a four-cylinder diesel engine, 4in bore and 5½in stroke, capable of developing 50·5 b.h.p. at 1450 r.p.m. In designing the tractor, provision has been made for limited adjustment of the wheel tread by changing the relative positions of wheel centre, clamps and rims. The front wheels, with 6 by 16 tyres, can be varied to give wheel centre of 50in to 58in, and the rear wheels, with 13 by 30 tyres, can be fixed at 56in, 60in or 64in centres. Transmission is through a single dry plate clutch, and the gearing is arranged to give five forward speeds between 2·39 and 14·95 m.p.h. and a reverse speed of 3·19 m.p.h. As an extra attachment

Another item of special interest which will be shown on the International Harvester Company's stand is a heavy-duty winch (Fig 6) which is made by T. T. Boughton and Sons, Ltd., Amersham Common, Bucks, for use with International crawler tractors. The winch is gear driven, dispensing with chain and sprocket transmission, and is flexible in operation, having both under and overwind with power reverse. It is fitted with a clutch and manually-operated brake, the tractor master clutch being used to apply the power to the winch. The 6in diameter drum can be made free-spooling instantly by using the winch clutch, thus allowing free run-out of the rope by hand without touching the other controls. The maximum rope capacities are 150 yards of ¼in diameter, 100 yards of ⅜in diameter, and 75 yards of ½in diameter, the line speeds claimed being: bare drum overwind, 14,500 lb at 82ft per minute; and bare drum underwind, 18,300 lb at 65ft per minute. Tapered roller bearings are fitted at all critical points of the winch to absorb heavy shaft loads, and the gears are of high-duty alloy steel.

This year, the Massey-Harris and Ferguson products will be shown on one stand occupied

Fig. 6—Boughton heavy-duty winch designed for International crawler tractor

by Massey-Harris-Ferguson, Ltd., of Coventry and Manchester. Some of the exhibits will demonstrate one of the first practical developments resulting from the amalgamation of the two firms ten months ago, which is the interchange of components between Massey-Harris and Ferguson machines. The Massey-Harris No. 750 combine harvester and the No. 701 baler are to be shown fitted with vaporising oil engines as made by the Standard Motor Company, Ltd., for Ferguson tractors. The Massey-Harris No. 745 diesel tractor, of 45 h.p., which was described in our issue of March 5th, will also be shown.

The Ferguson equipment, in addition to tractors, will include several new products. Among them there is a hedge cutter driven by a tractor-mounted "Hydrovane 25" air compressor. The arrangement of this equipment on

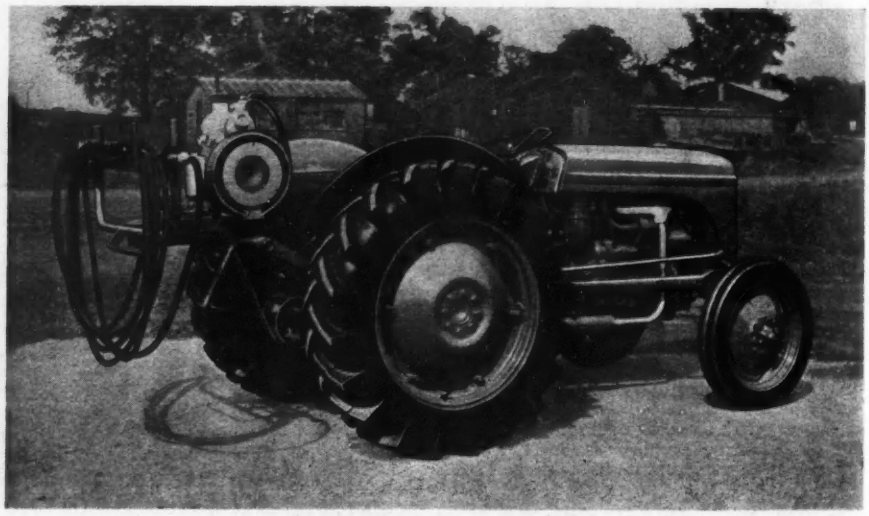


Fig. 5—Ferguson hedge cutter and "Hydrovane 25" air compressor in transport position. The compressor is driven from the tractor belt pulley

the tractor is shown in Fig. 5. The hedge cutter for which a silver medal was awarded at the recent Royal Highland Show, consists basically of a lightweight reciprocating knife, all its components being carried on the compressor mounting. The more important of these components are a light alloy comb, the blade, a motor unit, and the handle assembly containing a filter element and hand control valve. Two models of the hedge cutter are available, one having a 3in saw section on the blade, and the other having a 5in saw section for cutting thicker growth, including timber up to 6in diameter. At the end of the comb a saw guide is fitted to direct timber against the saw section. Blade changing and access to the motor are effected by unscrewing the handle assembly from the comb, the knife being secured by two guide screws. An L-shaped central handle at the back of the comb is easily adjustable to give suitable gripping positions for both left and right-handed operation, and the equipment of each cutter includes a 60ft length of pressure hose. The overall length of the cutter is 5ft 2in ; it weighs 8¼ lb, and with an air consumption of 18 cubic feet per minute at 100 lb per square inch its average reciprocations are said to be between 800 and 1000 per minute. The "Hydrovane 25" compressor has been designed for a maximum output of 25 cubic feet of free air per minute at a pressure of 100 lb per square inch. The compressor is carried on a steel mounting connected to the tractor's lower links and is belt driven from the pulley attachment. Whilst it is intended primarily to operate the new hedge cutter, it is, of course, suitable for several other kinds of farm and estate work.

Another new piece of Ferguson equipment is a dump skip, designed for mounting on the three-point linkage of the tractor. The skip weighs only 2¼ cwt, has a capacity of 10 cubic feet and is tipped by a release bar operated by the tractor driver. When the material has been discharged the skip returns automatically to the transport position.

(*To be continued*)

Pametrada's Progress Report for 1953

PAMETRADA has issued its report for 1953, which not only records the wide range of research undertaken but also indicates that a marked degree of progress has been achieved. Under its director, Dr. T. W. F. Brown, the Parsons and Marine Engineering Turbine Research and Development Association continued, during the year, to add to its volume of technical data. Thirteen research reports were issued to member firms and a number of contract reports were prepared and sent to the Admiralty and individual companies, while the staff presented several papers before the technical institutions. The report names the members of the committees and includes a brief review of the subjects considered at the committee meetings, and then goes on to note that fourteen provisional patents have been applied for, that five full patents have been granted and that several full patents have been granted in five foreign countries. A new general store was completed during the year and a test bed constructed for the high-temperature single-stage gas turbine, and the council also approved the construction of a workshop to house general purpose tools.

Design and Steam Turbine Research

During the year the staff was engaged upon sixty-four design inquiries which resulted in nine definite orders with the possibility of a similar number being placed. Among the ships with Pametrada machinery which were commissioned in 1953, the report lists H.M.Y. "Britannia," the Greek liner "Olympia," the Bergen steamer "Leda," and the oil tanker "World Enterprise," which had machinery designed to take steam at 850 deg. Fah. and 850 lb per square inch pressure. Other tankers were two for the Anglo-Saxon Petroleum Company, Ltd., and two for the Eagle Oil and Shipping Company, Ltd. It is specially noted that three naval vessels for the Venezuelan Government had machinery designed for economic operation at low cruising speeds without employing cruising turbines. Of the new designs completed during 1953, mention is made of one for the Canadian Pacific Steamship Company's new liner, and another for two large oil tankers, and also further single-cylinder turbines for a cross-Channel ship for the Isle of Man Steam Packet Company, Ltd., and for a freighter building in Canada. A reaction turbine blade vibration failure is recorded and it is stated that the association's work on vibration theory made it possible to make an estimate of vibration stresses to be encountered, so that the design was modified and the blade material changed from monel to stainless iron.

Experiments were carried out with regard to the method of handling turbines under standby conditions, and they included the fitting of small steam nozzles below the water surface in the condenser sump. By this means, the report records, a small amount of steam maintained the water close to boiling point, even with practically no vacuum in the condenser. Further developments have taken place in connection with the double casing h.p. turbine of a 950 deg. Fah. installation and a quarter size model has been built for load and thermal tests and loads, corresponding to 20*g* on full scale, have been applied. Following the completion of thermal tests, it is stated that load tests are to be carried out until permanent set occurs.

The Steam Turbine Research Department completed the full-scale testing of the Y.100 Naval Frigate machinery and, after dismantling, work was begun upon the erection of Y.E.A.D.1. high-pressure and temperature naval machinery. Early in the year steaming commenced on the experimental high-temperature turbine (Pamela), having turbine inlet steam conditions of 1100 lb per square inch and 1100 deg. Fah., and 117 hours' running has been carried out. Gland rubs have occurred and distortions of the turbine casing have been recorded and the restraint caused by heavy flanges noted. A redesigned sampling apparatus was built for research on non-condensable gases in steam, and a semi-micro gas analysis train was received, but according to the report faults in the equipment delayed the laboratory tests.

With regard to component research, a rig for turbine blade research was completed and proving trials run and the vibration spectra of batches of blades were determined in the laboratory before mounting. Proving runs, it is reported, have been carried out on the experimental rig and a cupro-nickel condenser tube with a thin silicone coating was tried out as a means of producing a drop-wise rather than a film-wise condensation of steam. Progress was made with the testing of furnace fuel oil service pumps and trials were completed on the Imo pump, which has been re-assembled for tests using cold oil. A length of Metalflex tubing has been subjected to a hydraulic pressure test of 975 lb per square inch, but testing under temperature conditions is still to be done. Other items of component research in the report include work on the turbine gland strip test, developments in connection with the high-speed wind tunnel, modification to the guarding valve for sensitive vacuum gauge and new designs for turbine cylinder joints.

Gas Turbine Research

It is stated in the report that modifications have been evolved to improve the manœuvring characteristics of the 3500 s.h.p. gas turbine, including the reduction of thermal inertia and an alternative casing design. Some low speed testing of the compressors was carried out and the turbine was run using Mothball residual fuel and also kerosene, both having a magnesium sulphate additive, the former fuel being used also with a magnesium acetate additive and later with ethyl silicate, an oil soluble additive. Late in the year there were trials to assess the overall transmission efficiency and after modifications further fuel tests were carried out. Tests suggested that vortex chamber erosion was caused by some form of cavitation and the trouble has been almost eliminated by a modification to the shut-off valve. It is mentioned in the report that a new control system has been devised to overcome present difficulties in the gas turbine control gear and from data obtained from tests on a model of this new system, components for the actual engine have been designed. Work has gone forward in the experimental compressor, the development of a combustion chamber and the use of hot wire igniters fitted with shields, and also on the development of ceramic turbine blades. Satisfactory operation was obtained with interchangeable fuel sprayers and research on blade cooling made some progress, while work was resumed on the construction of the porous walled test blade, in which a porous bronze wall is attached to a solid core by many small rivets. The report gives the results of the ash fouling and corrosion research scheme, noting that magnesium acetate appeared to increase the rate of fouling, and ethyl silicate gave a low fouling rate, while the exhaust gases were found to be practically free from carbon. Filters having a highly porous surface have been tested to absorb liquid ash from the gas stream, and a study initiated into the effect of sodium concentration upon ash corrosion, together with work upon the dispersal of such powders in fuel oils.

An examination of the 16,000 h.p. corrected gears, which were run to destruction, showed that the adoption of a helix angle modification to the pinions resulted in greater load carrying capacity, but that too great a modification would be detrimental at low powers. In another back-to-back test a set of gears, having a 3½ per cent nickel steel pinion and a forged carbon steel wheel rim withstood a tooth load of 1000 lb per inch face width at a pitch line speed of 250ft per second. Vibration was experienced at a higher pitchline speed and it is stated that a second gear to be tested has a 4 per cent nickel chrome molybdenum steel pinion and a wheel rim of 3 per cent nickel chrome molybdenum steel.

Transmission component tests have gone forward and the work on chamfered bearing performance was completed, and also the plain bearing tests using light oil, while the satisfactory performance of thin steel shell bearings has resulted in the production of a design of a marine bearing. During the year, tests on short journal bearings with L/D from $\frac{3}{4}$ to $\frac{1}{4}$ were completed, and indicated that the optimum ratio lies between $\frac{3}{4}$ and $\frac{1}{4}$. Other work on journals included questions of pressure and temperature distribution, and also slow speed tests, which included stopping and starting under load. The report records that tests with astern converter type "A" returned an efficiency of 43 per cent with an inlet pressure of 60 lb per square inch and an input speed of 2500 r.p.m., and 30 per cent with the flow area reduced by 50 per cent. A model of a type "C" astern coupling was tested and an efficiency of 56 per cent was obtained. Experimental work on disc lubrication has shown that an increase in oil viscosity raises the limiting stress below which pitting will not occur and further work is to be carried out using induction-hardened specimens. Some experience has been gained with a pneumatic bearing and a preliminary investigation made of tooth deflection, and the report mentions a study of the effect of surface roughness on hydrodynamic conditions in a wedge-shaped oil film, and fatigue tests on gear teeth of En 26 steel and 3½ per cent nickel steel.

The fourth section of the report deals with instruments and the various improvements and developments effected. A hydraulic torquemeter, in which the oil pressure difference between alternate vanes on the input and output shafts transmits the torque, is stated to be ready for trial. The next section is concerned with the development of new techniques such as lighting up naval combustion equipment, surface treatments for high temperatures and high-temperature brazing, and the report concludes with notes upon Pametrada research items covering miscellaneous metallurgical investigations, trial trips and field work.

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SITTING DOWN TO ONE'S WORK

There are, of course, people in this world who expect their employees when at work not only to work hard but also to look as if they were working hard. That, no doubt, is one of the reasons why so much machinery and so many appliances continue to be designed for operation by people standing up instead of sitting down. For there is a lesser air of activity about people who are sitting down. There is even a suspicion in some people's minds—we recall a memory from childhood of an over-active aunt—that to permit people to sit down is to encourage slackness. Such people, of course, would regard the provision of comfortable seats of ample width and a padded back rest as a positive invitation to sloth. Why, an employee might even fall asleep in one of them ! Yet, in fact, what is there wrong in making people as comfortable as possible at work ? There was a time, was there not, when drivers of omnibuses sat on hard uncomfortable boards with no more protection from the inclement elements than a multiplicity of overcoats and a stretched piece of canvas could afford. We cannot say that we have observed any noticeable falling away in their driving skill since they have been shut away in warm glass cubicles and seated upon upholstered comfort ; though, no doubt, their powers of caustic comment upon others' driving has suffered now that they are less audible than they used to be. In any event, we should retain a sense of proportion about this matter of standing or sitting. For as is remarked in a chapter of the Annual Report of the Chief Inspector of Factories, which inspired these comments " as a cause of fatigue, prolonged sitting is secondary only to prolonged standing." Perhaps that is why editors, in common with many other sedentary workers, feel so tired by the day's end, though we like to pretend the cause is the amount of work we get through. At least, the remark should propitiate those who have conscientious scruples about making their employees too comfortable.

In industry there is a growing tendency for managements to provide seats for workers even when they are not compelled by law to do so. It is a desirable tendency in more ways than one. For if seats are not provided all kinds of things tend to be pressed into service as a substitute, sometimes to their own detriment, sometimes to that of those using them. Factory inspectors, for example, have seen workers sitting on up-turned boxes, oil drums, and barrels, all of which surely could have been turned to some more suitable purpose and none of which can have been really comfortable. Then there was the operator observed sitting on the edge of an opened drawer which can hardly have been designed to carry such a cantilevered load. For ourselves, we remember in our younger days balancing upon a piece of four-by-four timber in the pattern shop ; we have even been reduced to sitting on the floor. Of course, it will be argued as a not-uncommon experience that even when seats are provided those for whose comfort they are intended often scorn to sit upon them. But this is not always, as might at first sight be supposed, merely another example of human contrariness. It may be, of course, that nobody wants to sit down. It is more likely that something is wrong with the seats ! For if seats are provided they need to be set in the right places and to be of the right height. To those whose opinion of human nature is low the fact that unsuitably designed, unsuitably placed, seats are not used ought, indeed, to be immensely encouraging. For does not their neglect suggest that far from workers being tempted into slackness by such consideration for their comfort, they are much more concerned to get on with their jobs ? Nor when seats are well-placed and of the correct height and are yet not occupied should one leap hastily to the conclusion from a first visit to the shop that they are not appreciated. " There is an amusing explanation as to why girls in an ice-cream factory were seen sitting on milk-drums instead of the more orthodox seats available ; it was a cold day and the drums were filled with warm water."

One of the objects of seating operators at their work instead of making them stand is to relieve fatigue and thereby to encourage higher output. Reading the Factory Inspector's report we could not help wondering how much of the work still done standing in many engineering works could, in fact, be done at least as satisfactorily sitting. Why are so many machines still designed to be tended by standing operators ? In the past when operators were constantly machining jobs of a " one-off " character, when the operation of the machine required the exertion of much muscular effort, when the worker was expected to grind his own tools, set his own machine, pick up rough parts for machining and set down or take away completed work, standing, because it allows so easily for movement around and about, was obviously more convenient than sitting. But nowadays, many machines are designed for repetitive production and controls are so well-placed that the operator hardly has the need to move his feet from the start to the finish of the day's work. Would there be any insuperable difficulty, for example, in designing a turret lathe for a sitting operator ? We do not know. Yet we do think that in the majority of engineering works a number of jobs are done standing that could as easily be done sitting. And of one thing we are certain. If it is observed of any operator of any machine that he customarily presses some unusual object into service as a seat, then it would be worth while examining whether some more satisfactory seating could be devised. Of course, the seat when provided should be designed for the job, or it will not be used. Any old seat just will not do. It is worth while noting—it is a point brought out in the Report—in what position the operator places his unorthodox seat and to what height he adjusts it. For that is where the new seat should be placed, and that is the height to which it should conform.

SOME PROBLEMS IN TECHNOLOGICAL DEVELOPMENT

No one can read Sir Winston Churchill's last volume of war history without being deeply impressed not only by the great skill of his wise leadership, but by the immensity in range and number of the political problems which arose during the war itself and, even more perhaps, by the unexpected manner in which it ended. As soon as one troublesome question was settled new ones arose and there seemed no end to the process. The fighting war is over, but much the same seems to be happening in the civil field. The applications of science and technology, whether alone or together, show us how the years of human life can be extended and means by which the world's food supply can be increased ; but in a recent discussion in the House of Lords on " World Population and Resources," followed by a broadcast talk by Lord Simon of Wythenshawe, who was one of the chief speakers in the debate, it was suggested that the dangers that lie ahead may rival those thrust upon the world

by the invention of the hydrogen bomb itself! This situation having arisen as a result of scientific and technological advances made in recent years, it is natural to ask whether further research can be counted on to show some way of preserving a right balance between population and food supply and so make the world a happier place to live in than must happen if affairs are allowed to drift. Lord Simon instanced particularly the use of DDT for the control of malaria in India with the consequence that the population was increasing at a rate of 5,000,000 a year, which is well ahead of the proportionate increase in the food supply; the great reduction in that country of the death rate, however welcome, has led Mr Nehru sorrowfully to confess that India would be a more advanced nation to-day if the population was about half its present figure. It is, of course, a mere arithmetical truism that for any area whatever in the world, action that steadily leads to a lower death rate and leaves the birth rate untouched would in the long run fail to provide, not merely enough food, but even standing room for its population!

The applications of the technology of to-day to the amelioration of human welfare can take many forms. Some of the early results were hardly what was expected; thus the spending of millions of pounds on an East African groundnut scheme was a costly failure, presumably because the technique on which it was based had been insufficiently tried out in tropical lands, even on an experimental scale. On the whole, as Professor Dudley Stamp points out in his excellent book "Our Undeveloped World," it is easier to increase production in temperate lands, where we have the great advantage that we are already tolerably familiar with the ways of Nature than we can possibly expect to be in the development of tropical areas, especially those previously forest covered. This involves the somewhat startling conclusion that the under-developed lands of the world must be thought of as including large parts of U.S.A., Canada, the Argentine and Australia. If the outputs of those countries could be increased to the level prevailing in certain of the lands of North-Western Europe, the gain in human welfare would be more rapid—and far greater—than could be expected to result from any equal technological effort in the tropics.

To engineers an even more striking event is that there is now making its appearance another outcome of the influence of modern technology upon human welfare—this lies in the growing number of industries in which the most advanced forms of design aim at the incorporation of automatic control, and even of operation, in certain types of factories. In a recent issue of an American technical journal it is claimed that such industries may come to include such widely different ones as those concerned with chemicals, fertilisers, telecommunications, electric power generation, cement, soaps and detergents; and in due course perhaps such others as textiles, iron and steel, printing and mining. Some of these forecasts may no doubt be held to arise from a certain amount of "wishful thinking," but at least they point to the bearing which advanced technology may have on the size and quality of the industrial population. It is likely to call for a number of highly skilled technicians associated with a small force of unskilled labour. One often hears experienced engineers of to-day express their regret at what they see as a regrettable tendency to relate pay rates between skilled and unskilled workers so as to leave little inducement to the young to go to the trouble of acquiring manual skill by putting in the years of apprenticeship which used once to be so common. But this feature may change in the coming years, with the need for the unskilled becoming less, and for the fully skilled becoming greater. The overall effect on human welfare may be hard to predict—except for the general consideration that the more work a robot mechanism can be made to do, and even to supervise, the more leisure (as well as lower production costs) there should be for mankind as a whole. This should be an attractive prospect for any political leadership which can rise to the level of solving the new social problems it will present.

Literature

Dislocations in Crystals. By W. T. READ. London: McGraw-Hill Publishing Company, Ltd., 95, Farringdon Street, E.C.4. Price 36s.

IN these days when the fundamentals of physics are progressing more and more on mathematical grounds, there is a need for trained and able physicists, who have the additional gift of lucidity, to explain in simple terms these mathematical arguments to the non-physicist. This is most noticeable in the study of the solid state of matter, where the progress has been such that it cannot readily be understood unless the reader is actually working in this field. Nevertheless, several excellent books on the subject have recently been published, in which many of the results have been arrived at by a physical argument, even if without mathematical rigour. The present book is a work of this kind.

One of the most striking examples of the failure of the elastic theory of matter is the mechanical weakness of single metal crystals, as compared with the calculated values. A difference of several orders of magnitude is involved. It was an attempt to explain this, and the mechanism of single crystal glide, which led to the postulation of the existence of the imperfections known as dislocations, some twenty years ago. (See Mott, *The Times Science Review*, Spring, 1954.) A dislocation is an atomic imperfection forming the boundary between the slipped and unslipped areas of a glide plane.

A dislocation can thus be imagined as a line of atomic misfit and Read presents a clear pictorial description of the geometry of dislocations. He describes only what is known, and limits his confirmatory evidence to that which is conclusive and not merely speculative. He encourages a physical feeling for dislocations, and each model is fully described by pictorial diagrams followed by a drawing of the atomic arrangement. Every effort has been made to make the chapters dovetail into each other logically, and each chapter is prefaced by the programme of that chapter and a summary of the conclusions reached. Much assistance is given to the reader by a large number of suggested exercises in the text, many of which are solved. There is also a set of exercises and problems at the end of each chapter, so that the book could quite well be used as a textbook on dislocations for students.

The book is divided into two parts. Part I deals with the simple theory of dislocations, in which Read sets out to develop and clarify the fundamental ideas of dislocations and discuss their geometry, dynamics, and the forces acting on them. Later he explains the ways in which the motion of dislocations can be used to explain some of the features of plastic deformation of metals. Much of this is pure conjecture. Indeed, it could be said that dislocation language is the fashion nowadays, often being used loosely to explain many metallurgical mysteries—creep, glide, recovery, recrystallisation, &c.—but not in a quantitative manner. At present there is no formal theory of dislocations which will enable the performance of a metal to be predicted in given circumstances. Although there has been a great deal of published work—mainly mathematical—on the geometry or dynamics of the movement of dislocations, there has hitherto been little success in using the theory to predict the behaviour of a metal as a whole, largely because a dislocation is an atomistic phenomenon, whereas the observed mechanical properties of a metal—strength, hardness, &c.—are macroscopic. Notable exceptions to this are the time law of strain-ageing, the observed spiral growth of crystals and the structure and energies of small angle misfit grain boundaries. Read discusses the last two in Part II of his book.

The development of the faces of crystals from vapour or dilute solution can be observed as a spiral growth, due to the operation of a screw dislocation, and this is explained diagrammatically and pictorially with the aid of many fine photographs taken from the literature.

The second example chosen by Read is the measurement of the energies of the boundaries between nearly parallel crystal edges. The quantitative agreement between measured and calculated energies and their variation with angle of misfit is most striking. These are the principal examples in which dislocation theory has predicted properties which have been verified by decisive experiments.

This book has very little to offer the practical engineer, since it attempts no quantitative explanation of creep, strength, or fatigue, about which the engineer, or the engineer-metallurgist, is primarily concerned. However, for the engineer interested in the physics or mechanics of the solid state, or in the strength of materials from a fundamental point of view, this book is a most readable and understandable introduction to dislocations.

The style of the book is rather "jerky," owing to the use of clipped sentences, but gradually this appears quite natural and gives the reader a feeling of what is actually happening to the atoms as the description proceeds. Thus, page 37: "Notice that the edge of the fault is a high energy imperfection, where the nearest neighbor relations are violated. (On the fault, only the next-nearest neighbors are unhappy)." Or page 61: "The following requirements nail down the direction of F. . . . Conclusion: F *is normal to the dislocation.*"

This book is an essential primer for those who have to take dislocation theory seriously, and who demand an understanding of the geometry and properties of dislocations before considering the more advanced books and articles. It should also commend itself to all post-graduate or honours metallurgists who are particularly interested in metal physics.

Letter to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

FRENCH LOCOMOTIVE EXPERIENCES

SIR,—Unlike some of your correspondents, I always appreciate Mr. Livesay's discursive accounts of his footplate experiences, which now and then form an agreeable contrast to the more closely reasoned and recondite fare provided in your admirable journal. The series dealing with French locomotive practice was especially interesting as it suggested a comparison with what has happened here since the nationalisation of the railways took place.

In this country a completely new range of standard locomotives has been evolved, many of which, speaking frankly, are no better than the corresponding machines that are already in service in large numbers on the former companies' systems. The S.N.C.F., on the other hand, has more wisely—in the writer's view—developed and improved the best of the designs of the companies taken over, and has only produced a few entirely new types of the most advanced design.

If British Railways had followed this policy there would have been the design and engineering effort available to give the necessary attention to the detailed improvement of the thousands of mediocre machines by which such a large share of the country's traffic, passenger and freight, is still hauled. Thus, the economic efficiency of the railway's motive power would rise much more rapidly and with less outlay than by the introduction of comparatively few new units even when these are markedly superior to the better of the existing locomotives.

Such improvements as rocking grates, self-cleaning smokeboxes and ash pans, continuous blow-downs, exhaust injectors or feed heaters and feed pumps, improved front end arrangements and steam controls, more efficient lubrication of working parts, could be applied as engines pass through the shops. Larger betterments such as improved cylinders, valve motions and boilers would be justified in many cases. The cumulative effect of this policy, which amounts to a virtual modernisation of the machines so dealt with, would be an appreciable reduction in haulage costs over a wide sector of the railway's operations which would help the country's transport until the benefits which will accrue from the schemes for large-scale electrification under consideration, materialise.

C. A. V. RUSSELL, M.I.C.E.,
M.I.Mech.E.

Saltburn by the Sea,
June 21st.

Engineering Models at the Institution of Civil Engineers

THE Institution of Civil Engineers' conversazione was held on Thursday, June 24th. This annual event, although primarily a social function, includes a display of engineering models in the Institution's library, many of which are of considerable technical interest and demonstrate recent advances in engineering. The Institution defines its primary aim as "the dissemination of the knowledge of engineering science," and the variety of models displayed this year reflected the scope of that definition. Some examples selected from the display are described below.

Laying Submarine Cables with Repeaters.—The development of repeaters which can be used with submarine telephone cables is a recent engineering advance which has brought with it new problems in cable laying. A model of a rig for a cable laying ship handling cables incorporating the British design of repeater was exhibited by Mr. A. C. Hartley and Mr. R. J. Ashby in conjunction with Johnson and Phillips, Ltd., and the Telegraph Construction and Maintenance Company, Ltd.

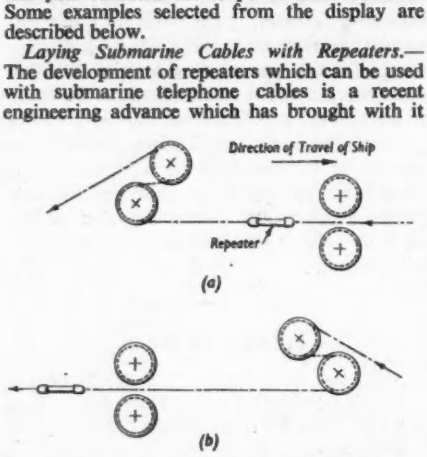


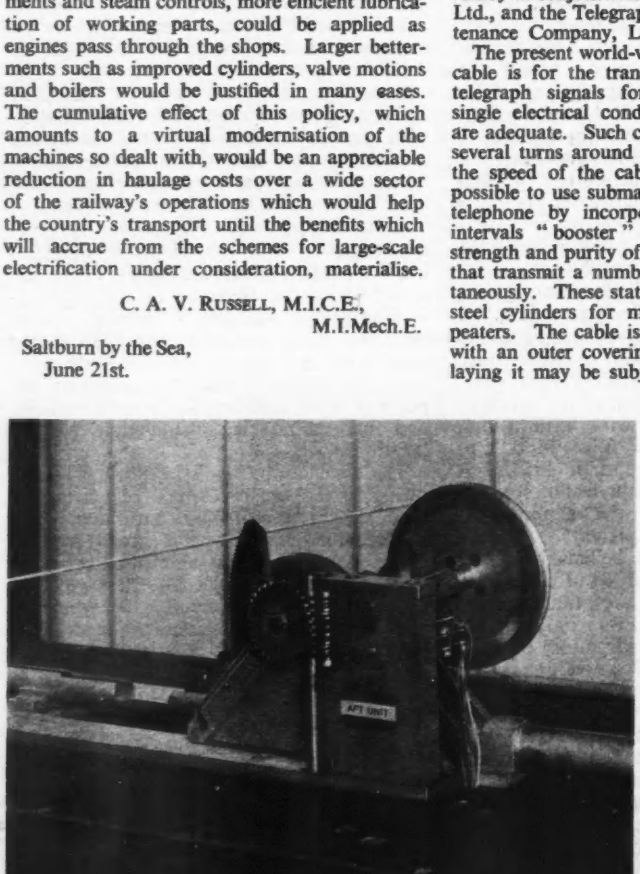
Diagram of Hartley-Ashby paying out machine for laying "repeatered" submarine telephone cable.

The present world-wide network of submarine cable is for the transmission of low-frequency telegraph signals for which a well-insulated single electrical conductor and earthed return are adequate. Such cables can be paid out with several turns around a braked drum to control the speed of the cable overboard. It is now possible to use submarine cable for speaking by telephone by incorporating at about 50-mile intervals "booster" stations to maintain the strength and purity of the high-frequency signals that transmit a number of conversations simultaneously. These stations, when condensed into steel cylinders for marine use, are called repeaters. The cable is a coaxial cable armoured with an outer covering of steel wires. During laying it may be subjected to a pull of nearly 15 tons in mid-ocean and rough weather. To avoid the possibility of damage in handling, a minimum radius of curvature to which it may be bent is specified. Particular care has to be taken to avoid bending it at its junction with the repeater. The repeater is an electronic unit inside a heavy steel casing, 11ft long, 1ft in diameter and weighing 10 cwt. It is expected to operate without maintenance or failure on the sea bed for many years. It enables a single cable to provide a large number of telephone links and speech in each direction.

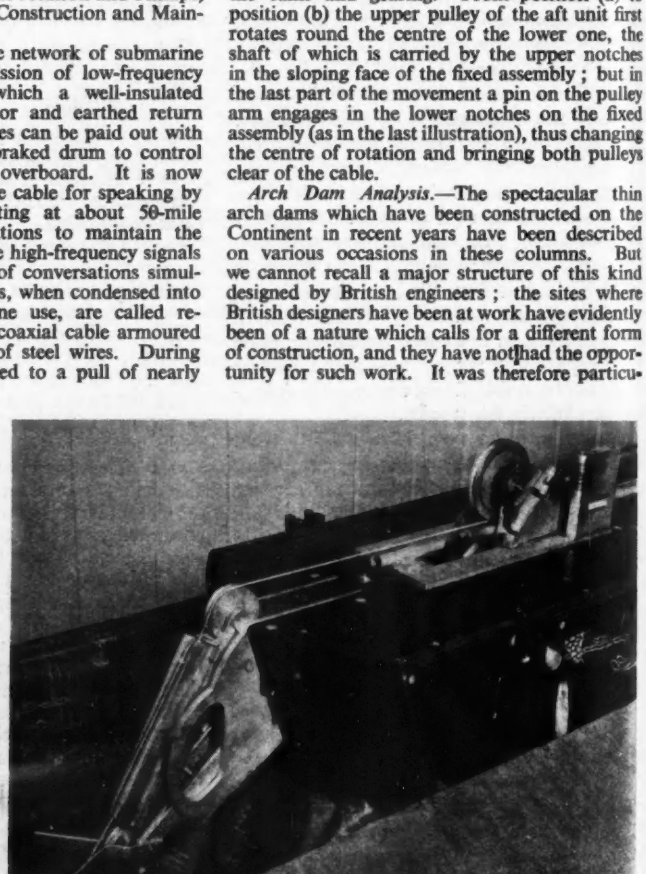
The model is one twenty-fourth full size and demonstrates the technique of laying the "repeatered" cable. Its principle is clearly shown in the diagram herewith. The cable is normally controlled by two vee pulleys, mounted on a common arm, as shown at (a). A second, similar, pair of pulleys further forward rests in an alternative position, clear of the cable. When a repeater passes the forward pair of pulleys the gear actuates automatically and the forward pair of pulleys rotates to engage the cable, and the aft pulleys rotate to free it, as shown at (b). The repeater travels in a straight line throughout this process. There is a pivoted cradle at the stern of the ship, which swings out when the repeater is in it, the cable passing over a pulley, thus avoiding any curvature close to the repeater as it leaves the ship.

The model does not truly represent the actual gear; in the absence of a pull overboard and for the sake of continuity the braking gear has been replaced by a driving mechanism and all the motors are electric. The first of the photographs of the model reproduced herewith shows the aft unit of the gear in the position (a) of the diagram. The second one shows the same unit in the (b) position, with the repeater ready to leave the cradle, which is in the tilted position. Movement of the pulley unit is effected through the cams and gearing. From position (a) to position (b) the upper pulley of the aft unit first rotates round the centre of the lower one, the shaft of which is carried by the upper notches in the sloping face of the fixed assembly; but in the last part of the movement a pin on the pulley arm engages in the lower notches on the fixed assembly (as in the last illustration), thus changing the centre of rotation and bringing both pulleys clear of the cable.

Arch Dam Analysis.—The spectacular thin arch dams which have been constructed on the Continent in recent years have been described on various occasions in these columns. But we cannot recall a major structure of this kind designed by British engineers; the sites where British designers have been at work have evidently been of a nature which calls for a different form of construction, and they have not had the opportunity for such work. It was therefore particu-



Aft unit of the cable laying gear. The repeater travels through the guide tube. The unit is in position (a) of the diagram.



Aft unit in position (b), with the repeater about to leave the cradle at the stern. The cradle is in the tilted position.

larly interesting to see models of the Dokan dam, now under construction on the Lesser Zab River in Iraq. Dokan dam is an arched structure with a maximum height of 380ft and a crest length of 115ft. It forms part of an irrigation and flood control scheme, with provision for hydro-electric power generation totalling 220MW in a power station next to the dam.

The design and analysis of arch dams has not yet reached finality of development, and different methods of design, all of them very complex and generally supplemented by model tests, seem to have developed in each of the different countries of Europe, where they have been built. British interests in this problem have now produced another new approach, which makes use of the relaxation method of analysis. The models shown at the Institution were cast in solid rubber, and were subjected to hydrostatic pressure and the displacements measured, to provide control data for the relaxation analysis. Four models were investigated, namely : a symmetrical dam in a vertical sided valley ; a dam in a V-shaped valley ; a preliminary design for the Dokan dam ; and the final design for Dokan dam. The models were shown by Mr. G. M. Binnie and Professor A. J. S. Pippard. The consulting engineers for the dam are Messrs. Binnie, Deacon and Gourley, and the contractor is Dumez-Ballot, of Paris. The relaxation analysis is being carried out at Imperial College.

Hydraulic Transport of Coal.—A transparent working model showing how coal can be raised from the pit bottom to the surface by water flowing upwards in a vertical pipe was shown by Mr. L. E. Prosser. The British Hydromechanics Research Association is carrying out research on the hydraulic transport of solids with particular reference to its use in collieries. Basic research is in progress to determine the pipe friction (and hence the power requirements) for carrying conditions, such as the size, density and concentration of solids, as well as problems of flow stability, degradation of the solids and erosion of pipes and machines. The practical application of this research, the Association states, must await the development of suitable machinery. In many cases the high pressures required preclude the simple method of passing the coal through a pump, and an alternative method is to feed the coal into a high-pressure water supply as shown in the model exhibited. In this application water is circulated by a low-head pump at the surface down to the mine and up again. Coal is introduced at the pit bottom by a reciprocating feeder and separated again at the surface. The model is capable of lifting 1 ton an hour through a 1in pipe. A full-scale installation could raise several hundred tons of 4in coal per hour through a 12in pipe.

Electrical Analyser for Pipe Networks.—A small model of a non-linear electrical analyser for investigation of flow in pipe networks was shown by Mr. T. M. Prus-Chacinski. The model represents an imaginary water supply network of pipes with twelve branches. Each branch is simulated by electrical group of small electrical bulbs in parallel and in series. The resistance of the bulbs and group bears a non-linear relationship to the current as in the formula :

$$v = K_e I^{1.85},$$

where

v = potential drop in volts,
I = current in amperes,
K_e = a constant,

presenting a complete analogy to the flow of water in pipes as in the Hazen-Williams formula :

$$H = K_p Q^{1.85},$$

where

H = loss of head in feet,
Q = flow in cusecs,
K_p = a constant.

To operate the model low-voltage current is fed in representing the inflow of water and the outflow points are represented by the non-linear resistor groups. Measurements of current and voltage drop can be read as loss of hydraulic head and discharge in any branch of the network by simple arithmetical conversion. Networks of any number of branches can be investigated by similar apparatus and hydraulic data quickly prepared from the simple electrical measurements, thereby saving the exhaustive work involved in calculation by mathematical methods.

Large Constructional Schemes.—Many of the models represented major civil engineering schemes which are now under construction or have recently been designed. The models in this category included representations of London Airport, Kwinana refinery in Australia, and the Admiralty oiling jetty at Devonport Dockyard, to mention three examples. Other models showed recording and measuring instruments of various sorts, ranging from a demonstration of the very precise measurement of length by optical interference (exhibited by the National Physical Laboratory), to a model trailer for measuring braking forces at high speeds in an investigation of skidding and of the landing characteristics of high-speed aircraft (Road Research Laboratory).

Swiss High-Power Testing Plant

The short-circuit testing plant which was installed at the Oerlikon Engineering Company's works in 1933 included an alternator with a making-capacity of 1000MVA and two transformers which allowed circuit breakers of 230kV and 400kV to be tested. To provide for the increased capacity required for testing modern switchgear, the company has recently installed a new high-power testing plant housing a 1500MVA alternator, with provision for a similar machine to be added later. With the co-operation of the Zurich Electricity Supply Authority line dropping tests can be done on circuit breakers using two 150kV overhead lines.

WE recently visited the works of the Oerlikon Engineering Company to see the new high-power testing plant which the company has installed for short circuit testing. It has an initial installation based on an alternator with a making capacity of 1500MVA and two 1300MVA single-phase transformers, whereby circuit breakers can be tested up to 380kV. Provision is made, however, for installing a second 1500MVA alternator and a third 1300MVA transformer, which gives the testing station a potential short circuit capacity of 3000MVA. There is also a mercury-arc rectifier installation, which makes available d.c. test voltages up to 3kV. In addition, through the collaboration of the Zurich Electricity Authority, the 150kV overhead transmission lines from Siebnen and Sils can be used for line dropping tests on circuit breakers.

The station is self-contained, the main building being equipped with a workshop where the test circuit breakers can be erected before being transferred on rails to one of five test cells (Fig. 1). Here a circuit breaker can be tested in one cell while other equipments are prepared for testing in adjoining cells. A separate building houses an observation and oscillograph room facing the test cells.

This new installation supersedes the original high-power testing plant which the company completed in 1933 ; it contained an alternator having a making capacity of 1000MVA and two transformers for testing high-voltage circuit breakers, and for facilitating studies of arc extinction.

Test Plant Layout

A simplified electrical diagram of the new test plant is shown in Fig. 2. Each of the two short circuit alternators *A*, which can be connected in star or delta and in series or parallel, supplies the busbar system through a back-up breaker *H*, reactors *C*, and a make switch *J*. From the busbar system, five outlets supply the test cells *G*. A further outlet feeds the high-voltage power transformers *F*, which step up the alternator voltage to the desired voltage up to 380kV for tests on high-voltage circuit breakers. A rectifier transformer *L*, which (in conjunction with the mercury-arc rectifiers *E*) can produce d.c. voltages up to 3kV, can also be connected to the busbar system.

The layout is based on the complete separation of the machine room and the test bays from the oscillograph and observation room. Three main conditions governed the general arrangement : (*a*) the inductive voltage drop in the 14kV lines between the alternator and test bay had to be kept as small as possible ; (*b*) facilities had to be provided for watching the short circuit machines and exciter sets during the test ; and (*c*) facilities also had to be provided for observing the equipment under test.

The physical layout can be appreciated from Figs. 1 and 2. The observation room (on the extreme right of Fig. 1) faces the test cells which occupy most of the front bay of the main building. The rear bay of the main building forms the machine room where the two short circuit alternators (*A*, Fig. 2) and the two impulse excitation sets *B* are installed. The two machines are arranged in such a way that the rotor of either one may be withdrawn for inspection while the other machine is in operation. Each alternator is provided with a separate impulse exciter which, at the moment of application of the short circuit, raises the voltage on the rotor to approximately twenty times its normal value by short circuiting the impulse excitation resistor *D*. A view of the machine room with the first alternator and the first impulse excitation

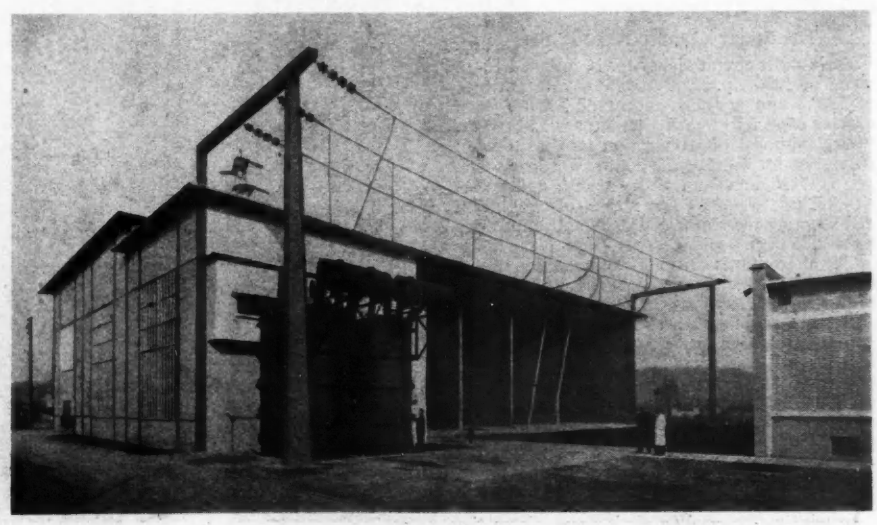
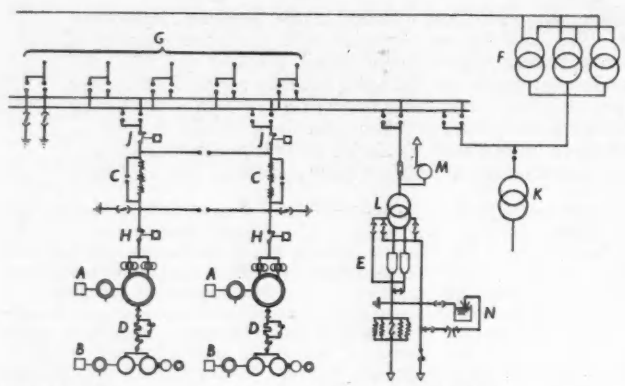


Fig. 1—High-power testing plant showing the main building with the h.v. outdoor transformers and the five test cells facing the observation building, which is on the extreme right

set is given in Fig. 3 ; the second set is to be installed later.

Between the machine room and the test cells are the rooms for the driving motor starters, the reactor rooms (*C*, Fig. 2) and the 6kV switchgear (comprising the supply cable switch and the feeder switches for the driving motors for alternators and exciter sets). Finally, behind the test cells are the 15kV shunts and voltage dividers for the oscillographs. The portion of the main building to the left of the test cells (Fig. 1) and behind the power transformers is a workshop where the equipment is prepared for testing. Completely assembled circuit breakers, up to the largest size, can be wheeled directly from the workshop to the test bays. The mercury-arc rectifiers (*E*, Fig. 2) are installed within the workshop area, but are fully screened. Direct current tests may be carried out in the extended end of the machine room.



A. Short-circuit alternators.
B. Impulse exciter sets.
C. Reactors.
D. Resistances for impulse excitation.
E. Rectifier installation.
F. High-tension power transformers.
G. Test cells.
H. Back-up circuit breaker.
J. Make switch.
K. Heavy current transformer.
L. Rectifier transformer.
M. Transformer for formation of rectifiers.
N. Loading resistors for rectifiers.

Fig. 2—Single line diagram of high-power testing station

On the high-voltage side, the transformers supply a three-phase line strung along the front of the test cells.

The machine room workshop and test cells occupy the full height of the building, but the central bay is divided into two floors. The first floor houses a control room for the machines and transformers, and a separate room contains the air filters for the cooling air for the alternators and the air coolers for the bearing oil of the two main machines. On this floor there are also two compressors and the two converter sets for direct current generation. In the main building there is a basement containing the alternator terminals with the link board (Fig. 6) for connecting the alternator in star or delta, and in series or parallel. The back-up breaker (Fig. 7), the making switch (Fig. 8) and the busbar system are also installed in the basement.

The Short Circuit Alternators

Each short circuit alternator is designed for a speed of 3000 r.p.m., a maximum rated voltage of 14kV, and a rated current of 3500A. The making capacity of each alternator is 1500MVA. Four methods of connection are available : star-series for voltages up to 14kV, star-parallel up to 7kV, delta-series up to 8kV, and delta-parallel up to 4kV. The means of supporting and securing the stator coil end connections can be seen in Figs. 4 and 5.

The alternator is driven by an induction motor of 1000kW, which is fed from the 6kV network of the Zurich Electricity Supply Authority. Each alternator, together with its driving motor and impulse excitation set, is mounted on a common foundation completely separated from the building. As the subsoil is not capable of carrying loads of this magnitude, the foundation of each alternator rests on thirty-five concrete piles, each 39ft long. The alternator and driving motor are bolted to the foundation block by twenty-four 2in anchor bolts to withstand torques of 2300 tons-ft.

In winter, the cooling air is drawn from the machine room, and after passing through the alternator, escapes into the machine room again, thus serving to heat the latter and the other parts of the building. In the summer the cooling air is drawn through windows on the first floor and after passing through the alternator is expelled through the windows. In the event of a fault on the alternator, the protective devices disconnect the driving motors of the alternator and the exciter sets from the supply, de-excite the alternator and trip the CO_2 fire extinguishing apparatus ; preloaded damper doors in the air channels leading to and from the machine are closed, and a door permitting closed-circuit circulation is opened. To bring the set to rest, the stator of the driving motor is excited with direct current and the rotor loaded with the starting resistor. Once the set has been brought up to speed and the rotor short-circuited, the starter moves automatically into the "braking" position, so that the braking mechanism is always ready to operate. The direct current supply for braking is delivered by the auxiliary exciter of the impulse excitation set, so that the latter is also brought to rest.

Before any of the machines can be started all bearing oil must be pumped by means of an auxiliary oil pump into a high-head reservoir containing 770 gallons of oil. To reduce bearing friction when starting the alternator a high-pressure pump forces oil into the bearings, thus forming a film capable of carrying the dead load of the machine. Simultaneously the supply from the reservoir comes into operation. Coupled to the ends of the shafts of the alternator and the impulse excitation unit are screw pumps, which even at 30 per cent of the normal speed of rotation deliver sufficient oil to lubricate the bearings correctly.

The Impulse Excitation Set.—Two series, connected d.c. generators, having a continuous rating of 1200A at 1·6kV, provide the impulse excitation. The short-time overload capacity of the group is 10,000A. The driving motor is a separate induction motor with a continuous rating of 800kW. Immediately before the short circuit is applied the driving motors of both the alternator and the impulse excitation set are disconnected from the 6kV supply network and the total short circuit power is supplied by the kinetic energy of the rotating parts. To enable the exciter set to deliver the necessary power for impulse excitation the rotational inertia is increased by a flywheel of 237,000 lb-ft². The impulse excitation is produced by bridging a resistor in the rotor circuit of the alternator, so that the voltage on the rotor is raised instantaneously to a value twenty times the original. Both direct current machines are excited by an auxiliary exciter connected through a coupling which can be disengaged during operation. The auxiliary exciter is rigidly coupled to its own driving motor which, when the impulse excitation is not required, the auxiliary exciter supplies the rotor of the short circuit alternator directly.

Electrical Equipment

If the circuit breaker under test should fail the circuit will be opened by the back-up breaker (Fig. 7), which is a reinforced "LDHR 20.25" air-blast circuit breaker rated at 20kV, 2500A, and having a symmetrical breaking capacity of 1500MVA at 14kV. To attain this high rupturing capacity, the circuit breaker was fitted with resistance shunts of low value.

The short circuit is applied by means of a "make switch" (Fig. 8), which must "make" the short circuit current from the alternator at a predetermined point of the voltage wave, the back-up switch and the test circuit breaker being already closed. To reduce the travel of the moving contact a high air pressure is maintained in the chamber and the closing speed is high enough to ensure that the contacts are fully closed before the short circuit current reaches its peak value. Closure is effected by springs which are charged by compressed air.

To obtain the desired short circuit current at any given voltage three reactors are provided in each phase, and each reactor may be connected in series or parallel. Thus, the short circuit current can be adjusted to values as low as 1 per cent of the maximum short circuit current. The coils of each phase are built into separate concrete cells.

As can be seen from the diagram (Fig. 2), provision has been made for each alternator to supply a separate busbar system, so that the two alternators may be run quite independently of one another. Each busbar consists of a double copper bar of 10mm by 100mm cross section, supported on "Orlite" post-insulators with corrugated surface, capable of withstanding a load of 2 tons.

Initially there are two (later, three) single-phase, high-voltage transformers, each of 1300MVA short circuit rating. By suitable winding connections (series, parallel, star, delta) voltages of 28kV to 190kV per transformer may be obtained. Single-phase transformers were chosen because of the greater operating reserve, as testing may still be continued on two phases

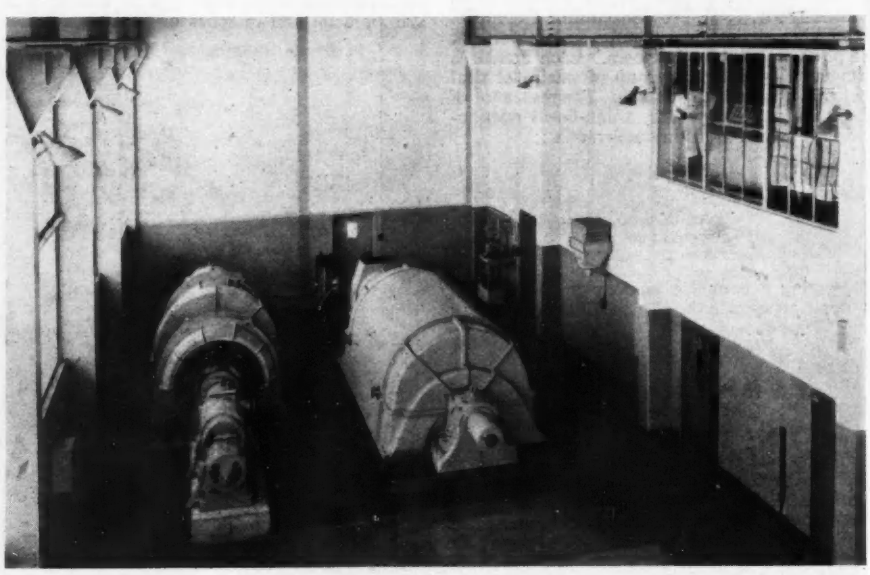


Fig. 3—Machine room of high-power test plant, showing, on the right, the control room overlooking the No. 1 short-circuit alternator and its impulse exciter set

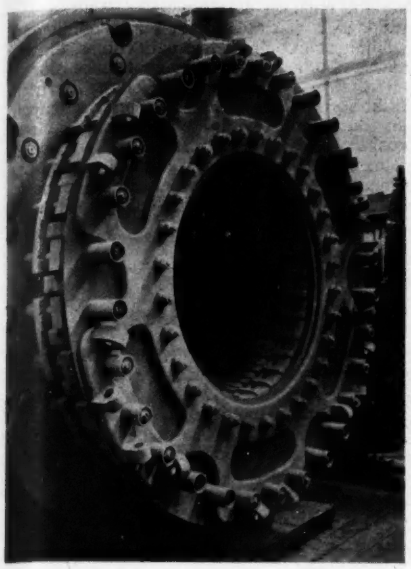


Fig. 4—Attachment and support of coil ends with bronze plates

if one fails in service. In addition, higher short circuit currents may be obtained during single phase tests by connecting two of the transformers in parallel. By connecting two high-voltage windings in series and earthing the mid-point it is possible to test circuit breakers up to 380kV.

A three-phase, high-current transformer (*K*, Fig. 2) is available for testing low-voltage circuit breakers, low-voltage fuses, and for making special tests on circuit breaker contacts, &c. It can be connected in star or delta, and can deliver currents up to 200,000A.

A 9000kVA rectifier transformer with twelve single anode rectifier units provides current for direct current tests. Direct current voltages of 250V to 3000V can be obtained by various transformer connections and by changing the alternator voltage. At 600V, direct current, breaking currents up to 80,000A may be obtained. The rectifier installation will be ready for operation later this year.

Three shunts for the measurement of current are mounted in a separate room immediately behind the test bays. The shunts are connected next to the neutral point, which is earthed for measurement. Voltage is measured in the normal manner with resistive voltage dividers. Direct leads between the measuring resistances and the oscillograph room are provided.

The Control Room and Protective Gear.—As has already been mentioned, the control room is on the first floor overlooking the machine room (Fig. 3). It houses all the control equipment, including that for starting and stopping the main driving motors and all the protection and supervisory apparatus. The relays provided for the alternator comprise those for differential, stator and rotor earth fault protection. On the incidence of an alternator fault the machines are immediately disconnected and de-excited, and the carbon dioxide fire protection equipment comes automatically into operation. The transformers are fitted with normal Buchholz protection. Also in the control room are the pressure gauges for the lubrication system. A smoke and fire warning device is provided for the protection of the reactor room ; the appropriate CO_2 equipment being tripped by hand from the control room.

The Test Cells.—The five test cells, two of which are for 14kV and the remaining three for voltages of 30kV to 380kV, are of reinforced concrete, and are completely open on the side facing the observation building. So that tests with heavy short-time currents may be made on all high-tension circuit breakers without the need to set up the breakers again, connections onto the alternator busbars are provided in each bay. There is also a separate hoist in each bay.

Fig. 5—Part of the end connections. The wedges are automatically tightened in the radial direction

Two of the test bays and also the three high-voltage transformers, are fitted with "Mulsifyre" fire-protection system.

The Observation and Oscillograph Building

The observation building faces the test cells at a distance of about 76ft. In the observation room (Fig. 9) there are two electromagnetic oscillographs, each with eight measuring elements for recording quantities such as current, voltage, pressure, contact travel, &c. A cathode ray oscillograph is used for recording the rate of rise or natural frequency of the recovery voltage. Co-ordination of the test sequence and operation of the oscillographs is effected

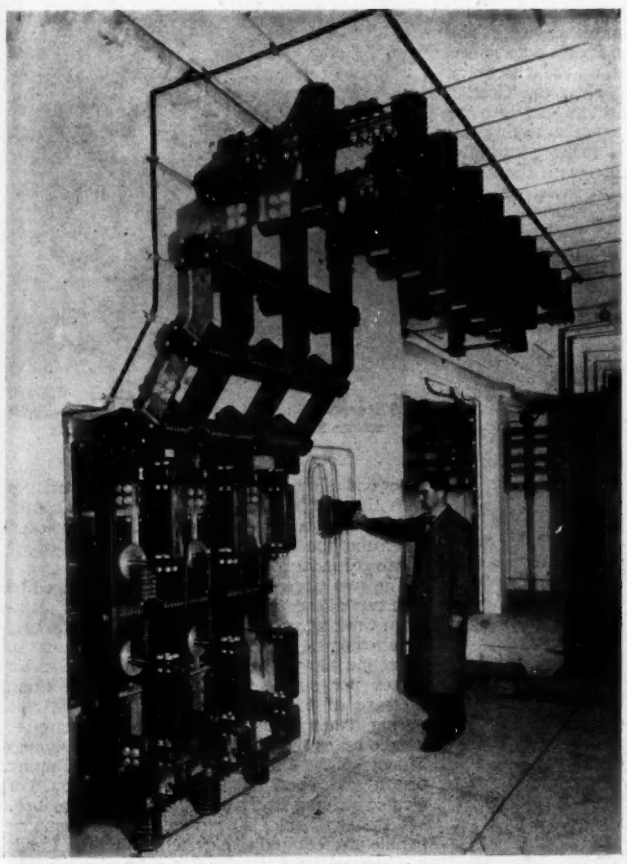


Fig. 6—Link board for connecting the alternator stator windings in star or delta, series or parallel

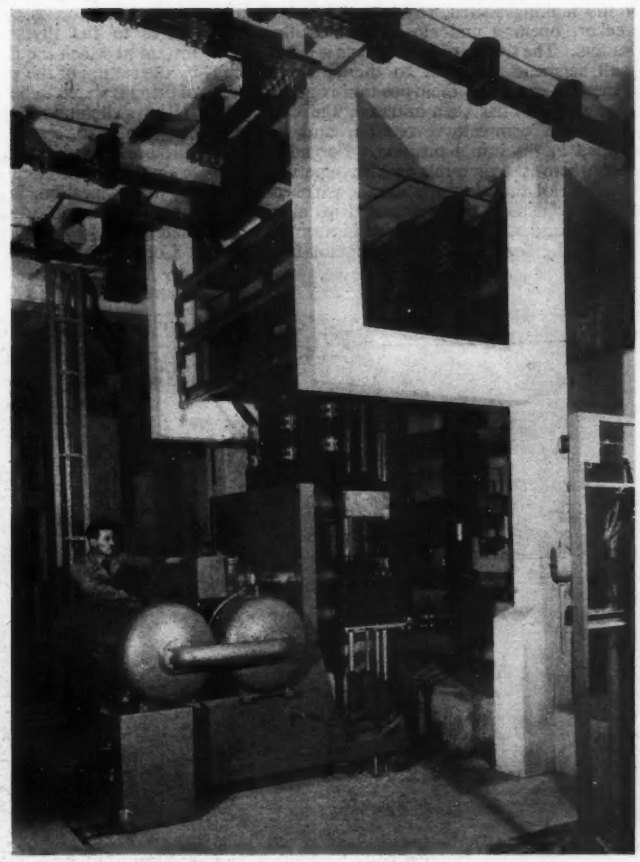


Fig. 7—Back-up circuit breaker, a modified "LDHR 20·25" air-blast equipment, rated at 20kV, 2500A, with a symmetrical rupturing capacity of 1500MVA at 14kV

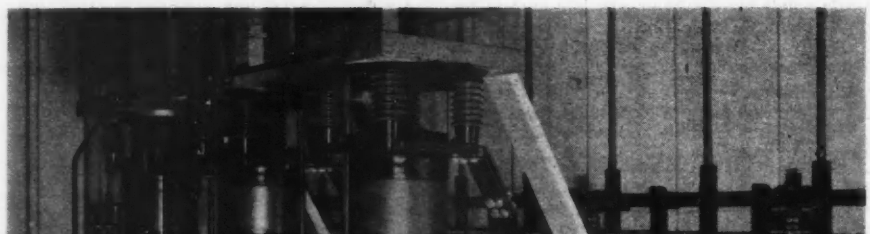


Fig. 8—Spring-operated, compressed-air-charged make switch

automatically by a motor-driven centrally located cam sequence switch, which is built into the control desk. An individual control desk is provided for each alternator, while the apparatus for governing parallel operation of both alternators is installed between the two desks. To initiate the test, the sequence switch is started by the engineer in charge, standing at the observation slit. The sequence switch then takes control of all stages of the test, such as cutting off the driving motors, applying the impulse excitation, applying the short circuit by means of the making switch, tripping the test circuit breaker, opening and closing the oscillograph shutters. The timing of these events is effected by small segments attached to the circumference of the disc cams and their position is adjustable. After each test has been initiated, the camshaft makes one complete revolution, and is then stopped in the initial position. For additional safety there is a time relay which supervises the operation of the sequence switch, which after a definite adjustable time interval, trips all circuit breakers and stops the whole equipment.

Normally for the testing of circuit breakers, only the maximum value of the alternating current component is of interest. Therefore, the synchronous switching-moment selectors have been provided for both cam sequence switches. These selectors can be connected in any phase at will, and can control both the making switch and the test circuit breaker. The cam sequence switch performs the approximate preselection, while a thyratron control device selects the exact instant of switching. The voltage output of a measuring generator, which is rigidly connected to the shaft of the main alternator, is conducted through a phase shifter to the thyratron control device. The instant at which the thyratron fires is determined by the setting of the phase shifter. The accuracy of firing is stated to be about ± 1 deg. electrical.

The switching-moment selectors can also be very useful for special tests, such as testing circuit breakers with high peak making currents, testing air-blast circuit breakers with the maximum arc duration, investigating fuses, performing short circuit tests with high-current asymmetry, &c.

Communication between the machine room and the engineer is by two-way loud speaker equipment. The observation and oscillograph building also contains two dark-rooms, drawing office and other offices and a conference room.

With the co-operation of the Zurich Electricity Authority the Oerlikon Engineering Company can carry out line-dropping tests on circuit breakers. The two Z.E.A. 150kV lines from Siebnen and Sils to the Oerlikon substation pass behind the testing station and can be connected through isolators to the high-voltage busbars in the station.

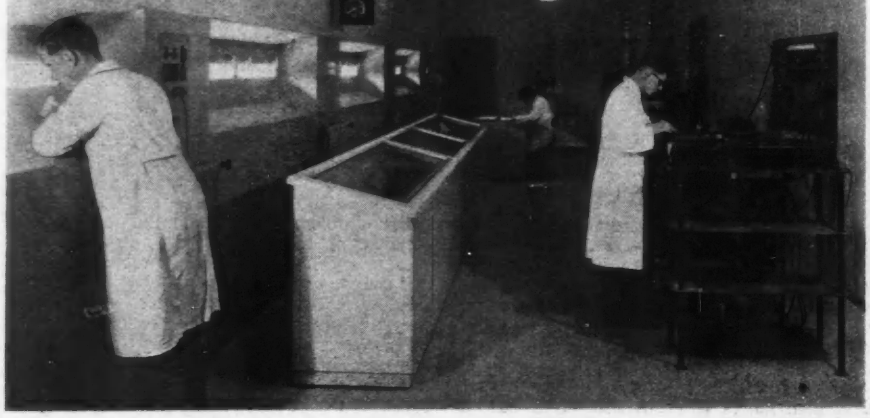
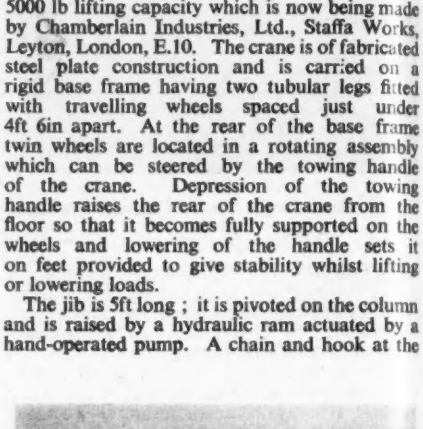


Fig. 9—Observation and oscillograph room with observation slits overlooking the test cells. The cam-actuated sequence controller is in the glass-topped cabinet and the oscillograph equipment is on the extreme right

Hydraulic Shop Crane

We reproduce on this page a photograph of a new portable hydraulic shop crane of 5000 lb lifting capacity which is now being made by Chamberlain Industries, Ltd., Staffa Works, Leyton, London, E.10. The crane is of fabricated steel plate construction and is carried on a rigid base frame having two tubular legs fitted with travelling wheels spaced just under 4ft 6in apart. At the rear of the base frame twin wheels are located in a rotating assembly which can be steered by the towing handle of the crane. Depression of the towing handle raises the rear of the crane from the floor so that it becomes fully supported on the wheels and lowering of the handle sets it on feet provided to give stability whilst lifting or lowering loads.

The jib is 5ft long ; it is pivoted on the column and is raised by a hydraulic ram actuated by a hand-operated pump. A chain and hook at the outer end of the jib can be adjusted in accordance with the required height of lift. The range of lift through the ram is 6ft and using a shortened chain the hook can be raised to a height of 9ft above ground level.



5000 lb capacity portable hydraulic shop crane with 6ft stroke and maximum lifting height of 9ft

The two stage hydraulic pump is arranged to give two alternative rates of delivery and maximum working pressures to suit different working requirements. With both of its pistons in operation the pump has an output of 4·5 cubic inches per stroke with a maximum working pressure of 630 lb per square inch. At this setting twenty-four strokes of the pumping handle raises the jib hook through its maximum lift of 6ft. For heavy duty one pumping piston is operated giving an output of $\frac{1}{4}$ cubic inch per stroke at 5000 lb per square inch. With this setting 320 strokes of the pumping handle are required to elevate the jib 6ft. Loads are lowered by gravity, with the speed controlled by the setting of a needle valve through which the oil in the ram cylinder is allowed to escape back to the main reservoir.

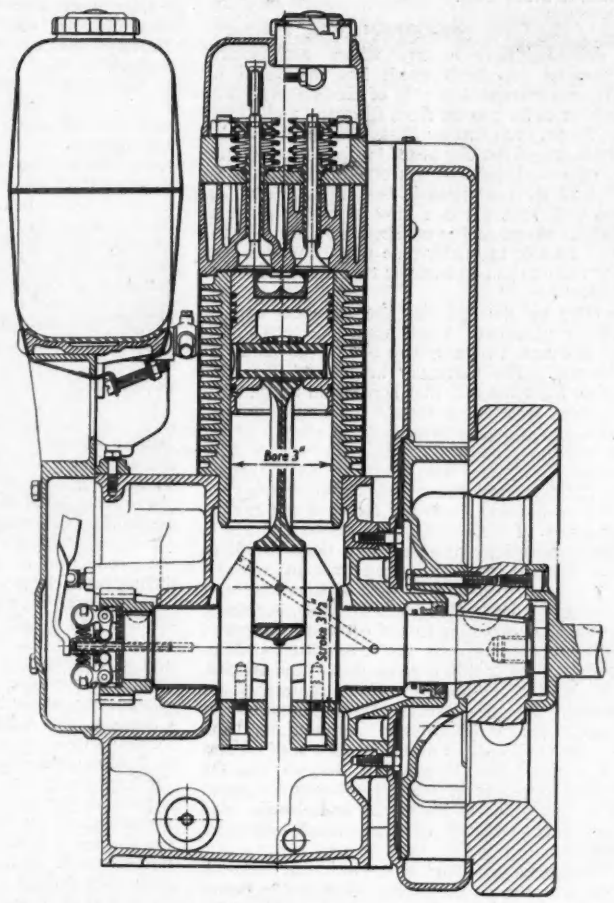
3½ H.P. Air-cooled Diesel Engine

An air-cooled, four-stroke, single-cylinder diesel engine has now been placed in line production by R. A. Lister and Co., Ltd., of Wroughton, near Swindon. Prototypes of this engine have been running since 1947 under simulated Arctic and tropical conditions and some 80,000 hours' test running has been obtained, 10,000 hours' non-stop running at full load being achieved with an ambient temperature of 132 degrees Fah. and maximum humidity. Using fuel and lubricating oil appropriate to Arctic conditions and a standard oil starting unit the engine can be started at temperatures as low as −19 deg. Fah.

The engine, which is illustrated, was designed to run at 2000 r.p.m., but it has a conservative twelve-hour rating of 3½ h.p. at 1800 r.p.m. and develops exactly half that power at half the speed. The fuel consumption is 0·55 lb per b.h.p.-hour at full load and the engine has a dry weight of 250 lb.

It has a bore and stroke of 3in by 3½in and a brake mean effective pressure of 64 lb per square inch at 1500 r.p.m. (3 b.h.p.).

Light alloy has been used for the multi-vane fan, engine shroud, fuel pump housing, end cover and top cover. A cast iron crankcase of rigid construction is fitted with a large inspection door sited low down on the casing. This is easily removable to give immediate access to the big end shell bearings, connecting-rod and the pressure lubricating pump. The crankshaft is designed in excess of Lloyd's specification and is 2¼in in diameter, and special attention has been given to crankshaft balance. It is cross drilled, thus providing two oil feeds for pressure lubrication of the big end bearing. Both cylinder liner and cylinder head are of close-grained cast iron and the piston is in low expansion aluminium alloy. The combustion is located in a specially designed and patented piston head. A closed toroidal chamber of high-temperature steel is recessed asymmetrically within the piston head and is thermally insulated. The chamber has been developed to function in conjunction with the inclined nozzle of the fuel injection system. Much of the development of the engine has centred around this combustion arrangement. Fuel oil is gravity fed from a tank of 1 gallon capacity to the oil filter and from there to the cam-operated C.A.V. fuel pump. The metered feed of fuel oil is delivered to the injector, which is housed in its own air-cooled sleeve and forced into the combustion chamber through the annulus of the pintle type nozzle for which the self-cleaning characteristics and reliability are acknowledged.



General arrangement of the engine showing combustion chamber insert

A reduction gear is built integrally so that either half engine speed or full engine speed is available. The crankshaft gear is recessed to house a simple mechanical governor which operates the fuel pump rack. Above 1500 r.p.m. the settled variation of engine speed is maintained between ±1·5 per cent.

A plunger pump operates from an eccentric on the camshaft to give pressure feed lubrication to rockers and crankshaft (the camshaft is equipped with three self-lubricating bearings). This system has a hydraulic unit which keeps the pressure constant and ensures an even supply of lubricating oil during the suction strokes of the pump. A wet sump is employed.

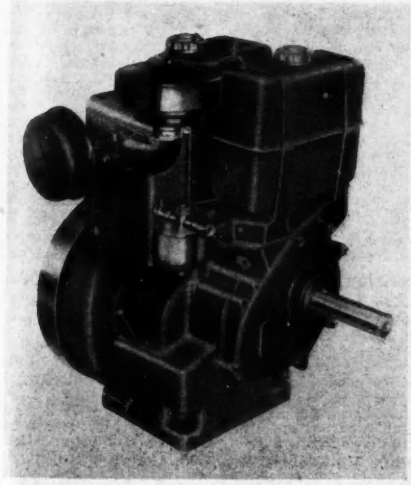
Air cooling is maintained by a curved vane aluminium fan of generous size. It is 12in in diameter and is driven at the speed of the flywheel. The fan has a large number of small blades aligned axially at the disc rim and is housed in a special shroud which delivers the cooling air to the cylinder head and cylinder housing substantially at the rate of 85 cubic feet per minute per horsepower over a large speed range.

The crankshaft is taper-ended to take the flywheel which is keyed and held by a retaining screw. Pulley drives are available either from bolt-on pulleys fitted to the engine flywheel or from keyed pulleys mounted on a crankshaft extension which can be fitted to the flywheel. Pulley drives can also be taken from the half-speed shaft.

Apart from normal hand starting, electrical starting is an optional extra. A compression release system is fitted for easy starting and is actuated by a small lever working through the top cover to the cylinder head. Unified threads are used wherever practical in the manufacture of the engine.

The engine is suitable for many kinds of civil construction plant, agricultural machines and industrial plant. The company believes it to be specially suitable as an auxiliary and propulsion unit for small craft, and in this connection it is pointed out that the engine retains the same holding-down bolt centres and crankshaft heights as the company's "D" model petrol engine, and it therefore becomes easily convertible as an exchange unit.

Prototypes of the engine have been working for some time on a variety of marine duties. It was in anticipation of this application that, to meet Lloyd's requirements, the crankshaft was made 2¼in in diameter. In marine auxiliary units a compressor can be driven from the half-speed shaft and the engine speed used to drive a generator and/or centrifugal pump, whose efficiency is greater at the higher speed.



Four-stroke air-cooled diesel engine suitable for marine and industrial uses. It develops 3·5 h.p. at 1800 r.p.m. and weighs 256 lb

Extension of Research Laboratory at Banbury

New extensions to the research laboratories of Aluminium Laboratories, Ltd., have been completed recently at Banbury and the buildings, which were begun in 1951, have added a further 44,000 square feet to the existing floor area to make the total available 65,000 square feet. The new premises, designed by Sir Percy Thomas and Son, Cardiff, provide a completely integrated modern laboratory fully equipped for the wide range of research which is carried out by a staff numbering almost two hundred.

The research department is divided into four main divisions, namely, chemistry, metallurgy, physics and engineering. The chemistry division has two sections; one is concerned with the chemistry of aluminium surfaces and problems that affect the surface finish of the metal and the other provides an analytical service for materials handled by other divisions. The use of aluminium for canning is the main study of one laboratory and it is fitted with prototype equipment for drawing and lacquering aluminium containers and for testing their behaviour when packed with different products. Long-term research into the metallurgy of aluminium with particular emphasis on fabrication and utilisation problems, is the main concern of the metallurgy division, which has four sections dealing with castings, wrought and physical metallurgy, alloy development and corrosion.

The compilation of physical data on aluminium, the application of physical methods to research and the provision of an instrumentation service for laboratories are the three aspects of the work carried out by the physical division. Four sections make up the engineering division, that dealing with structural engineering carries out studies to provide theoretical treatment of design problems and is equipped for the full-scale testing of aluminium alloy structures and structural components. The problems of hot and cold working forms part of the work of the metal deformation section, which also studies the formation and effects of residual stresses. In the third section the emphasis is upon the provision of information on the mechanical properties of aluminium alloys and the study of practical problems such as those concerned with fatigue. The function of the mechanical engineering section is to provide a general service for the development of machinery and equipment and to prepare test pieces.

Iron and Steel Institute in Sweden

SINCE the war we have accompanied the Iron and Steel Institute upon its Summer Meetings abroad to Norway, Austria and Holland, and given illustrated accounts of these visits. This year the Institute took its members to Sweden. But because, owing to a clash of dates, we were able to attend only a part of the meeting in that country ; and because, in consequence, we were unable to see very much of Swedish technical accomplishments we intend, on this occasion, only briefly to refer to the meeting, confining our remarks, as usual, only to those visits and functions at which we personally attended.

GOTHENBURG

The bulk of the members attending the visit to Sweden sailed from Tilbury on the evening of June 5th, and arrived at Gothenburg on the morning of June 7th. Gothenburg is a charming city where styles of architecture have clearly been heavily influenced from Western Europe. Indeed, members of the Institute who visited Holland last year had a queer feeling in walking its streets of being on familiar ground. The feeling is explained by the fact that the city, founded as late as the 17th century, was laid out by the Dutch. Some of the canals that they dug—laying out the city on lines similar to those of towns in their homeland—have since been filled in ; but enough remain, in conjunction with the harbour, to retain for Gothenburg a certain Dutch flavour.

June 7th was Whit Monday, a holiday that the Swedes, like the English, celebrate. Members were therefore taken on a sight-seeing excursion to Langodrag, a charming spot on the sea coast only a few miles out of the city, and a great yachting centre. On the following day we chose to visit A. B. Ferrolegcringar at Trollhattan, and to visit the hydro-electric power works at the same place. The firm was founded in 1913, being attracted to Trollhattan by the availability of cheap electric power. It is a maker of ferro alloys. At first it produced only high-carbon ferrochromium and by the middle twenties it had a larger production of that alloy than any other European producer. Nowadays it produces ferro-vanadium, ferro-molybdenum, ferro-tungsten, ferro-titanium, ferro-tantalum-niobium and ferro-niobium-tantulum. Chrome alum is also made. All operations are performed in electric furnaces ; and as is so usual in Scandinavia, and so unusual here, Soderburg electrodes are used.

The first hydro-electric power plant at Trollhattan was built in 1910. During the recent war a further plant was erected. Power is generated in Kaplan turbines using a head of about 100ft. Kaplan turbines were chosen because of the wide variation in output demanded of the station, which, on account of the great storage capacity available, acts to balance out fluctuations in the power that can be generated in other stations less well-placed for storage. The new power house has been cut out of the rock and roofed over in concrete and proved to be a very impressive place. The total capacity amounts to 250kW. Another matter of engineering interest at Trollhattan concerns the canal which connects Gothenburg with Stockholm. At this point, ships and barges have to be lifted some 100ft in a flight of locks. The first attempt to make such a flight of locks was made as far back as the mid-eighteenth century, but was a failure. However, in 1801, a successful flight was constructed and the rock cutting still exists, though the timber gates have gone. A new set of locks was built in 1840, and they are still serviceable, though now seldom used. The modern locks lift ships in three stages of rather more than 30ft apiece.

In the evening there was a dinner at Gothenburg Town Hall ; and, in company with the majority of the members, we left the city afterwards for a night journey to Vasteras. There we chose to visit the works of A. B. Svenska Metallverken, makers of sheet, strip, rod, and wire in copper and copper alloys, including brass and bronze, and aluminium wire, used mainly for the manufacture of Feral steel-centred cable. The equipment turned out to be very fine, the copper bar mill, the brass strip mill and a brass extruding press attracting particular attention. The output of this works amounts to close on 50,000 tons per annum.

In the evening members moved on by special train to Stockholm.

STOCKHOLM

Stockholm is a city whose architectural character has been much less influenced by Western Europe than that of Gothenburg. The influences have come from Germany and Russia and from even further East. But the particular character of the city is set by the intrusion into it of broad waterways from all directions so that all its more notable buildings are sited on the waterside. It is a most attractive place in high summer, as the members saw it. What it may be like in winter-time when daylight lasts little more than an hour or two is quite another matter !

Here on the first day the members had an easy programme. A visit was made to the park of Skansen, a mile or two out of the centre of the city. The particular interest of this park arises from the fact that here, from all parts of Sweden, have been brought old timber houses, including complete farmsteads, a church and a manor house, some dating back several centuries. They have been re-erected and furnished in contemporary style ; and certain crafts such as glass-blowing, weaving, &c., are still carried on. One of the surprising things to a visitor is the spacious interior of many of those dwellings that look so mean and small from the outside. We confess to having become so interested that we missed the last coach taking members back to the city, so having to find our own transport !

In the evening there was a reception at Jernkontoret, the central organisation of the Swedish Iron and Steel Industry which represents the industry in all questions of common interest except labour relations. Jernkontoret was founded as long ago as 1747 and it is of interest to remark that at that time Sweden was the largest producer of iron in the world. Apart from its financial affairs the organisation also encourages research and takes much interest in technical training.

On Friday, June 11th, technical sessions began at the Riksdaghuset. But for ourselves we chose to take part in an excursion to Svenska Diamantbergborrnings A.B. This firm specialises in the making of equipment for core-drilling for seismic and prospecting purposes. Particular interest was taken in the various methods of mounting diamonds in the boring heads and in the design of the boring machines. The latter have to have almost as many movements as a machine tool—rotation for the boring tool, axial movement to accommodate the downward progress of the bit, and inclination to permit inclined bores to be put down. In addition there need to be provided hydraulic cylinders to take part of the weight of the rods so that the pressure between bit and rock can be adjusted and a winch to take the weight of the rods when they are being lifted or lowered or a new length added. The British subsidiary of the firm has been undertaking, since the war, much boring for the National Coal Board.

In the evening of the same day, by invitation of Jernkontoret, members were able to attend a special performance at the Opera House.

On the following day the technical session was continued at the Riksdaghuset. Many members, however, chose, like ourselves, to become better acquainted with Stockholm. In the evening there was a banquet and dance at the Town Hall. That is a building erected in the early 'twenties, which attracted a great deal of architectural interest at the time and which, upon the closer inspection which a visit to it permitted, turned out to deserve all the commendation it had received. In particular the Blue Hall, so called not because it is blue—the prevailing colour is, in fact, the natural deep red of its brickwork—but because the architect originally intended that its coloration should be blue, provided a really delightful setting for the dancing that followed the banquet.

There our experience of the meeting ended. During the following week parties of members travelled in special trains to Lapland, Varmland and Dalecarlia. We were, however, unable to accompany any of them, and our account therefore comes to its end.

Search for Natural Gas

LAST week members of the technical press were able to visit the site at Crowborough Warren, Sussex, where the Gas Council is engaged on deep drilling operations for supplies of natural gas. Speaking during the visit, Sir Harold Smith, chairman of the Gas Council, said that the search began six months ago and was planned to continue for a period of five years. He emphasised that there was no guarantee of early success since a large amount of exploration work had to be done and experts assessed the chances of successful borings at about one in five. The decision to embark on the search was largely determined, he said, because of the rapid rise in the price of coal which had resulted in an overall increase of cost to the gas industry of £35,000,000 per annum since 1949. Another factor was the scarcity of good carbonising coals, supplies of which, he thought, were being delivered to industries which were capable of converting them into heat with the same efficiency as the gas industry. The industry, by means of research, was endeavouring to improve the efficiency of carbonising processes and to develop methods of using low quality coals for gas making, but felt that it must not neglect the possibilities of obtaining gas from other sources. Sir Harold pointed out that developments for the production of electricity by atomic power did not mean cheaper electricity, but the discovery of a natural supply of gas would mean that cheaper gas would be available. Drilling had already taken place at Cousland in Midlothian, and survey work was under way in Yorkshire and Lincolnshire. At Crowborough, after prospecting work by the D'Arcy Exploration Company, the Ashdown Well No. 1, which is located within an anticline some 24 miles long by 5 miles wide, is being drilled by the Bremner Drilling Company, Ltd. Drilling has reached a point at the level of the Purbeck or Portland formation where there is a possibility of gas being present, and indeed, a slight show of gas has occurred. Should gas not be found at this level, then drilling will continue to the Corallian formation at a depth of about 2500 ft. At the site there is a mobile laboratory in which the permeability and porosity of the core samples can be assessed to give a measure of the possible gas content. The equipment includes a pressure gauge, which is fitted with a twelve-hour clock, and automatically records pressures in the bore-hole.

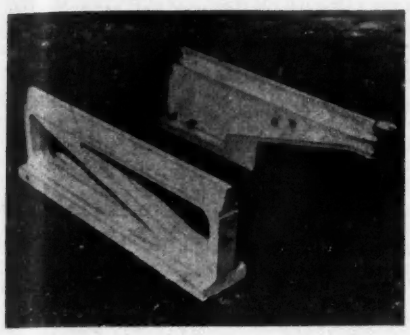
MANUFACTURE OF OIL DRILLING EQUIPMENT IN NORTHERN IRELAND.—At a recent meeting of the Northern Ireland Production Council, Lord Glentoran (Minister of Commerce) announced that the Hughes Tool Company of Houston, Texas, is to set up a factory in Belfast, and that the company has been allocated one of the Government-built factories at Castlereagh. The factory is nearing completion and covers an area of over 86,000 square feet. The Hughes Tool Company is a large producer of oil drilling equipment in the world, and it is stated that production in Northern Ireland is likely to be concentrated on the manufacture of standard-size drilling bits, for sale mainly in the soft currency area.

GASKET COVERS OF POLYTETRAFLUOROETHYLENE.—Gasket covers of Polytetrafluoroethylene, or p.t.f.e., have previously been made by cutting from large cylinders of the material and we are informed that a new method for moulding such gaskets directly from "Fluon" powder has been developed by the I.C.I. Plastics Division. In this process, the powder is spread in an annular compression mould, and then a ring of tracing cloth, which reaches to the outer wall of the mould but not to the central portion, or vice versa, is placed on this layer. A further layer of powder is placed on this cloth and compressed to about 3000 lb per square inch. The tracing cloth, which is made in two halves so that it can be withdrawn easily, is then removed and the moulding is heated to about 360 deg. Cent. for about one and a half hours to obtain a strong heat and chemical-resistant gasket cover. It is pointed out that any smooth, powder-impermeable ring which allows the transmission of pressure to the powder may be used in this process in the place of tracing cloth. By an extension of the process, bellows can be made if required.

Prefabricated System of Prestressed Concrete Construction

WORTHING Secondary Technical School, the construction of which is now in progress, is the prototype structure of a prefabricated method of construction known as the "Intergrid" system. A number of standard precast concrete units are employed in this system, and the floor and roof structures are formed by prestressing together, on the site, an assemblage of such units. Typical examples of the system are shown in the accompanying illustrations.

The design is based on a 3ft 4in horizontal module and a 10in vertical module. It aims to give a considerable flexibility of layout by the use of standard components, suitable for buildings up to four stories in height, with self-centring floor and roof construction and a cladding system erected from inside without the use of scaffolding, which will allow doors and windows to be placed as required. An open truss system is used, for lightness, and so that service pipes can be freely accommodated within the construction depth.

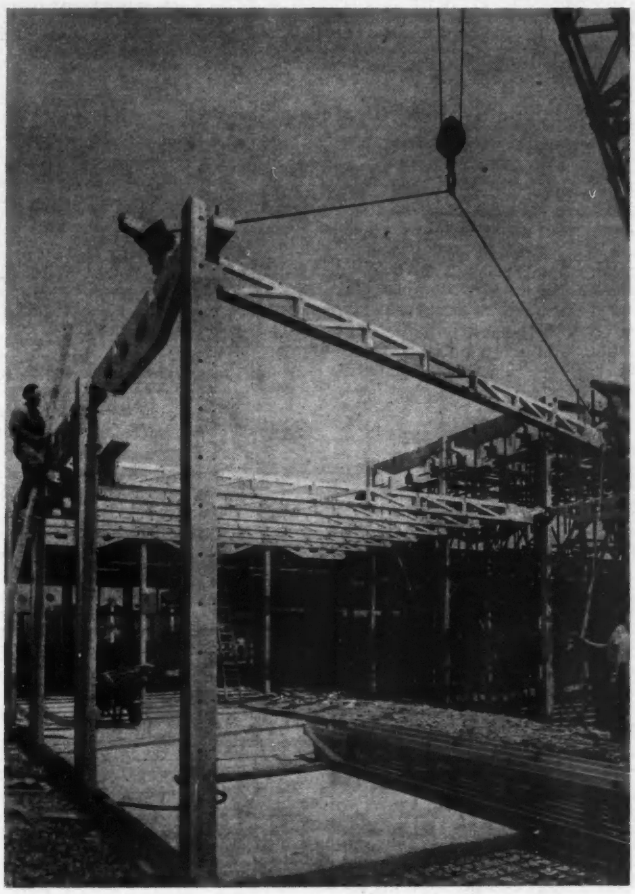


Precast units for the main beams. The required number of intermediate units, as shown in the foreground, are placed between two end units and the assembly is prestressed

The floor and roof system consists of a grillage of post tensioned beams at 3ft 4in centres in both directions supported on boundary beams and column heads. The columns are at either 6ft 8in or 10ft centres around the perimeter of each structural bay. The maximum spans for the bays are 23ft 4in × infinity (primary span × secondary span), 26ft 8in × 40ft, 33ft 4in × 33ft 4in for floors, and 36ft 8in × infinity and 40ft × 40ft for roofs. Recent developments in the beam system promise to increase these spans.

The columns are precast to a standard section —6½in by 4½in overall, with grooved sides—and varying lengths on a 10in module, and are pretensioned with four 0·2in diameter wires. There are four main types: three for external walls and one for internal positions. For multi-storey construction there is in addition a cruciform column, measuring 6½in by 6½in along each axis. Ground floor columns are designed for erection in sockets cast in the foundation bases. On the upper floors the columns stand on the column heads of the ground and lower floor columns and are pin-jointed. All external columns have projecting nibs on each side and holes cast at 10in vertical centres for the fixing of cladding slabs and windows. Column heads have been designed to cater for every possible beam fixing condition which may arise.

Three kinds of beam are used to form the floor and roof system. The boundary beams, surrounding the perimeter of each structural bay, are of reinforced concrete, and are cast in two standard lengths of 6ft 8in and 10ft. They are supported on the column heads and in their turn support either one or two beam connections. The primary beams are placed at 3ft 4in centres across the shorter span of each bay. They consist of two solid precast end units, 3ft 4in long, and a varying number of identical precast lattice intermediate units, 3ft 4in long and 12½in deep. These units are assembled and prestressed together on the site before erection. Jointing is done across the section of the top and bottom booms only; ciment fondu is used. The Freyssinet system of prestressing is used, with two-wire anchorage, either four or eight 0·2in diameter wires being used per beam, according to its size and loading. The secondary beams are of units similar to those of the primary beams, but with a projecting web, for self-centring on the flange of the primary beams. They are placed at 3ft 4in centres in the transverse direction and are assembled unit by unit between the primary beams. After the units are jointed the prestressing wire is passed along the groove in the outer edge of the lower flange of the beam and through a hole left for it in the primary beam; stressing is carried out on completion of each structural bay.



Erection of a main beam. This illustration shows the reinforced concrete boundary beams, the column heads, and the grooves and holes in the columns for fixing the precast cladding units

The floor and roof slabs, which are of solid, unreinforced concrete, are nominally 3ft 4in square, 2½in thick at the edges, 1½in thick at the middle and slightly domed. They are placed in position within the squares formed by the top flanges of the beams. When grouted into position they act with the beam system to form a rigid monolithic horizontal slab. Roof light kerbs are substituted for roof slabs where top lighting is required.

In this building the staircase wells were, as an expedient, cast *in situ* but a precast system of construction has now been satisfactorily developed for use with subsequent construction. The external walling is of cavity construction, consisting of an internal skin of 3in precast panels with a honeycomb finish, and an external skin of precast concrete cladding panels. Three different kinds of exposed aggregate finish are used. The panels fit into the grooves of the columns and are fixed by tapered reinforced concrete pins.

Ultrasonic testing has been used for the precast structural units, and 60 per cent of all units manufactured have been tested. A system of relating pulse velocity to compressive strength has been evolved, and a basic figure established, which is regarded as a minimum for immediate "passing" of the units. If the minimum is not reached further mechanical testing is applied.

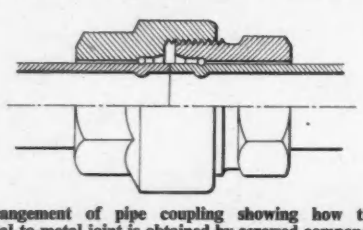
A point of particular interest to the structural engineer is that the floor or roof assembly of each bay—that is, the primary and secondary beams and plain concrete floor slabs—acts as a monolithic unit, thus giving a greater margin of strength than would a similar assembly acting as individual units. The columns are pin-jointed at top and bottom, and horizontal loads are taken by the cladding. The evolution of a satisfactory range of standard units involved very close co-operation between the architects and the structural designers. Worthing Secon-

The completed roof structure. The primary beams, secondary beams and floor slabs act as one monolithic unit. The service pipes within the structural depth may be noted

dary Technical School was designed for the West Sussex and Worthing Education Committees by the architects and building branch, Ministry of Education, in association with the county architect's department, West Sussex County Council. The specialist engineers are the Pre-Stressed Concrete Company, Ltd., and the contractor is Gilbert-Ash, Ltd. With the exception of the prestressed columns and staircase stringers, which were cast and stressed by the Liverpool Artificial Stone Company, Ltd., all the precast concrete units were manufactured by Mono Concrete, Ltd.

Couplings for Metal-to-Metal Pipe Joints

A NEW pipe coupling which is now being made by Langley Alloys, Ltd., Langley, Slough, Bucks, provides a metal-to-metal seal and the component parts of the couplings themselves do not come into contact with the fluid in the pipe. The pipe ends have to be prepared for the fitting of the couplings, and two simple hand-operated machines have been developed to enable this work to be done by unskilled labour on site if required. The couplings can be



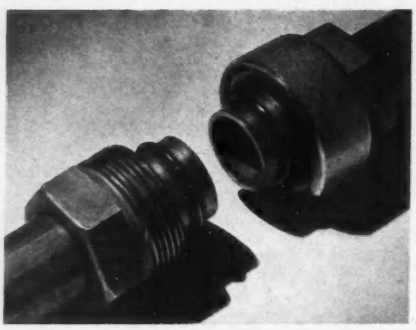
Arrangement of pipe coupling showing how tight metal-to-metal joint is obtained by screwed components through circlips in grooves in the pipes

quickly and easily applied and the joints dismantled and remade as often as required. At present, couplings are available for pipes up to 2in nominal outside diameter, and we are informed that in tests such joints have carried liquid pressures up to 20,000 lb per square inch.

The simple design of the new coupling can be seen from the drawing we reproduce herewith. It consists of a male and female parts, which fit freely over the pipes to be connected, and two circlips which register in grooves rolled in each pipe a short distance from the ends. The opposing pipe faces are machined square and flat before the joint is made. As the assembly is screwed together the shoulders formed at the back of annular recesses in the male and female parts register on the circlips. Through these circlips, as the pressure is increased, the coupling members force the flat ends of the pipes together to form a metal-to-metal, liquid-tight joint with an unbroken inner surface.

It will be appreciated that with a joint of this kind the material used for the pipe can be selected in accordance with the liquid to be handled, but standard materials can be used for the coupling parts as they do not come into contact with the liquid. When it is required to couple two different sizes of pipe together a modified design of male part is used with a tapering ring fitted on the smaller diameter pipe. This ring comes into contact with the fluid and in special applications should be of the same material as is used for the pipes.

The design of the two machines used for preparing the pipe ends, and their method of operation can be seen from the illustrations at the foot of this page. The pipe end-facing machine is arranged for bench mounting and on it the pipe is clamped squarely in the centring vices. A tool slide mounted on the spindle of the headstock is rotated by a handle as the tool



Component parts of Langley pipe coupling with circlips in position ready for joint to be made

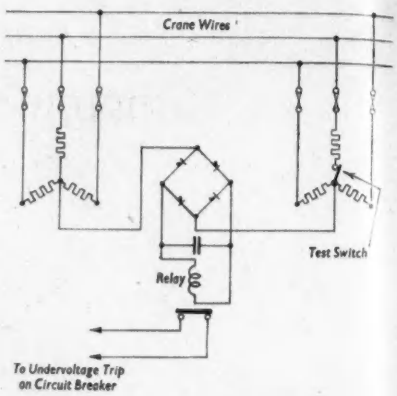
is fed across the face of the pipe. In-feed of a small hand wheel moves the headstock along its ways.

In order to roll the groove the pipe is clamped in a vice and the rolling machine is operated by hand. It is placed in position on the pipe with a central spigot of appropriate size registering in the bore. The two backing rollers on a spindle-operated slide are then screwed up to support the pipe squarely. The grooving roller on a slide on the opposite side of the machine is then fed into the pipe as the machine is rotated round the pipe. This in-feed of the grooving roller and rotation of the machine is carried out until the required groove depth and profile are obtained. It is stated that the small "dimple" formed in this grooving operation does not create any undesirable pocket or interfere to any appreciable measure with the free flow of the liquid in the pipeline.

Protective Equipment for Overhead Crane Conductors

A SIMPLE form of protective equipment for the three-phase "down-shop" leads of overhead cranes has been developed by the British Thomson-Houston Company, Ltd., Rugby. It is designed to remove the hazards arising from the breakage of one of the bare conductors supplying the cranes. The protective system is designed to ensure that breakage of a conductor operates a relay, tripping the circuit breaker and interrupting the supply to the crane wires.

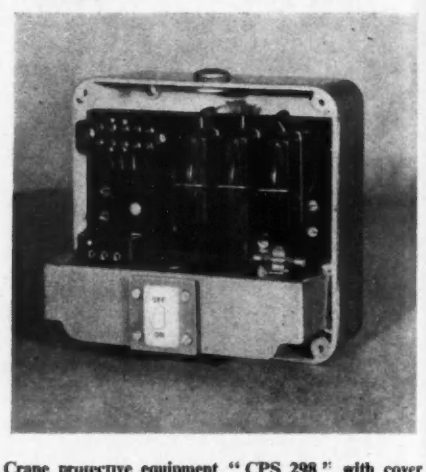
The scheme consists essentially of an impedance network, connected in star to each end of the three-phase "down-shop" leads, as shown in the accompanying diagram. The two star points are connected through a rectifier feeding a sensitive relay. Normally, with all three conductors intact, the two star points are at the same potential and there is no



Key diagram of crane protective equipment

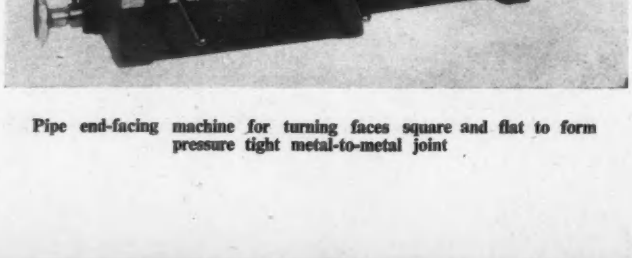
current through the relay. Should one conductor break, however, the two networks immediately become unbalanced, a voltage is established between the two star points, and the relay is energised. A normally closed contact on the relay is connected in series with the under-voltage coil normally present on the feeder circuit breaker; thus the relay, in opening, causes the circuit breaker to trip and interrupt the supply to the crane wires.

The protective equipment is housed in two small die-cast boxes approximately 7in by 7½in by 5in deep, as illustrated here with the cover removed to show the withdrawable chassis.

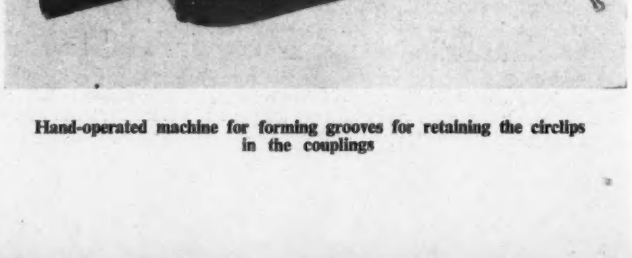


Crane protective equipment "CPS 298" with cover removed to show withdrawable chassis

One box, the "CPS 298 A," unit accommodates the first network together with three fuses, the sensitive relay, rectifier unit, and condenser, The other box, the "CPS 298 B" unit houses the second network, three fuses, and a test switch. The test switch is connected in one line of the network so that by opening the switch the effect of a broken conductor is simulated and the breaker should trip. Only one pilot wire is required between the two networks at the ends of the conductor wires.



Pipe end-facing machine for turning faces square and flat to form pressure tight metal-to-metal joint



Hand-operated machine for forming grooves for retaining the circlips in the couplings

The American Scene

(By Our American Editor)

THE SEAWAY AT LAST

WITH the signing of the St. Lawrence Seaway Bill by President Eisenhower on May 13th, a political controversy which extended over a quarter of a century has come to an end. The Congressional approval of the Bill now ensures American participation in the Seaway scheme and provides for the creation of a St. Lawrence Seaway Development Corporation to construct navigational facilities on the New York side of the international section of the St. Lawrence River at a cost of 105,000,000 dollars. Furthermore, the Bill authorises the Corporation to co-operate with the St. Lawrence Seaway Authority of Canada in carrying out its mission. There has been certain political pressure in Ottawa aiming at a Canadian refusal of American participation in the construction of the Seaway, but it is believed that, ultimately, Canada will go along with the proposed joint construction scheme. As was to be expected, there is a certain gloom to be felt in East Coast ports, such as New York, Boston and Philadelphia, which fear a serious loss of shipping business as a result of the future diversion of cargo to the Seaway. On the other hand, there is much rejoicing in the great industrial ports and cities of the Great Lakes area—Buffalo, Cleveland, Toledo, Detroit, Milwaukee, Chicago and Duluth, to name the principal ports on the American side—and in the fertile agricultural area they also serve. None of the lake ports will become seaports in the exact meaning of that term. The great liners such as the "Queen Mary" and "Queen Elizabeth" will not be making Detroit a port of call. The improvements on the rapids sections of the St. Lawrence permit only 10,000 to 12,000-ton vessels drawing no more than 25ft to 26ft of water, to climb the 602ft high and 2200-mile-long ladder of locks and channels to the highest lake—Superior. Nevertheless, the Seaway opens up new vistas for every food grower and machine maker between the Alleghenies and the Rocky Mountains. The cost of transporting a ton of general cargo by railway from Cleveland to East Coast ports is 13 dollars. When the St. Lawrence Seaway is completed in five or six years, the cost of transporting the same cargo from Cleveland to the North Atlantic by ship will be 1·70 dollars, including the probable tolls of 1·25 dollars a ton. It is this prospect of an 87 per cent decrease in transportation cost that excites the areas along the Great Lakes, and the necessity to provide such cheap passage for the newly discovered, iron ores of Quebec, Labrador and Venezuela to the Great Lakes mills gave the final impetus to the Seaway drive in the United States.

The passage of the Seaway Bill has stirred the imagination of the residents of every port along the Great Lakes as nothing else has in years. Actually, the construction of the Seaway was practically ensured almost a year ago when the Federal Power Commission issued a licence to the Power Authority of the State of New York to join with the Hydro-Electric Commission of Ontario in building a dam and power plant near Massena, New York. That scheme was the key to the construction of a deep-water channel past the rapids section of the St. Lawrence River. The town of Massena borders the 36 miles long International Rapids of the St. Lawrence, where the bulk of the American work on the Seaway will be done. It is in this area that the United States will build two lateral canals, one 8 miles long and the other 3, as well as three locks, each 800ft long, 80ft wide and 30ft over the sills. The only other major work will involve lowering scattered rock shoals in the Thousand Islands area to the depth of 27ft. The new law authorises the St. Lawrence Seaway Development Corporation to issue bonds to the value of 105 million dollars to cover the United States' share of the estimated project cost. Canada, acting through the St. Lawrence Seaway Authority of Canada, stands ready to spend up to 300 million dollars. This authorisation, however, was voted when it was uncertain whether Canada would undertake the project alone. An expenditure of no more than 200 million dollars by Canada is now in prospect. Apart from deepening the Welland Canal, which links Lakes Erie and Ontario, Canada will be concerned chiefly with dredging and canal and lock construction in the 68-mile stretch downstream from the International Rapids to Montreal.

It must be realised that the completion of these Canadian and American works of the Seaway scheme constitutes only a beginning. They will provide a 27ft channel inland only as far as Toledo, the westernmost port on Lake Erie. Up river channels of only 21ft in the Detroit, St. Clair and St. Mary's Rivers and in Lake St. Clair, bar three of the Great Lakes—Huron, Michigan and Superior—from the major ocean shipping. Furthermore, from Detroit to Buffalo, along the southern shore of Lake Erie, there is at present not a single pier with enough deep water off it to handle the projected Seaway traffic. Toronto and Hamilton, on the Canadian side, are in the same situation. And the same is true of Chicago, Milwaukee, Duluth and other ports on the three northern and western lakes. Only Cleveland has more than 25ft of clearance in the harbour area behind the breakwater and it is on that part of her lake front that she has developed a small boat basin, a municipal stadium, an airport and park areas. All the commercial docks in the harbour have only 25ft of water. Before the expected volume of 50,000,000 tons of cargo a year can flow through the Seaway in economically profitable vessels, those channels and harbours must be deepened and in many cases new facilities must be built ashore. There will have to be much legislation by the Great Lakes States to prepare for these new developments. Only Milwaukee, of the major lake ports, now has an authority similar to that of the port of New York. Riparian rights are in dispute in some areas. The City of Cleveland and various railway interests compromised a fifty-year quarrel last year over rights on the Cleveland lake front, but the compromise settled no legal points. Legislation also will be needed in Illinois and New York, and probably in Michigan and Minnesota. What the railways will do to help along developments remains to be decided. They bitterly opposed the Seaway, and hold title to much of the developed lake fronts. They have been defeated; however, now they may join. The development committees in many lake ports have declared that now is no time to spare the dredges, or the dollars. The Seaway has added a new and brighter hue to to-morrow's dawns for them, and they are determined to seize the opportunities which this important engineering work is bringing to their doorsteps.

Power Generation from Nuclear Energy

The U.S. Atomic Energy Commission has approved separate study agreements with the American Machine and Foundry Company and the Babcock and Wilcox Company of New York, and the Bendix Aviation Corporation, of Detroit, Michigan, looking toward the practical application of atomic power and its by-products. The agreements are in keeping with the current American policy of encouraging the participation by private industry in the development of economic nuclear power, and bring to eleven the number of studies being conducted by individual concerns or groups of companies now in the Industrial Participation Programme of the A.E.C. The three companies have been engaged for some time in studies of the feasibility of nuclear power reactors. The Babcock and Wilcox Company is a manufacturer of power station equipment and has designed and manufactured atomic energy equipment for the A.E.C. Its study will concentrate on the design, development and manufacture of equipment necessary to the operation of nuclear power plants. The work of the Bendix Aviation Corporation will deal with the future of atomic power and its by-products, anticipating the development of new reactor designs and the discovery of new uses for radio-active isotopes or fission products. The company has made four reports to the Commission on small reactor power plants and one report on the commercial utilisation of radio-active isotopes. Much of the atomic energy experience of the American Machine and Foundry Company has been in the development and manufacture of control mechanisms. The company will make a study of machines and equipment associated with nuclear power plants and will explore the feasibility of developing low-power reactors for industrial research.

The three new projects will run for one year, with all costs being borne by the companies. The Commission will assist the companies by making available information essential to the studies and providing consultation services by its personnel. At the end of the contract period the companies will submit to the A.E.C. reports which summarise their findings and their recommendations for action by the Commission. As in other agreements made by the Commission, title to inventions and discoveries and disposition of reports on the studies will be determined by the Commission, subject to certain licence rights reserved to the three companies.

The Atomic Energy Commission has also entered into an agreement with five electric utility companies situated in the Pacific North-West under which the companies will study the feasibility of designing and constructing a nuclear reactor for the production of electric power. This study is the first to be undertaken by concerns in the North-West, where there is a growing demand for new sources of power. The utility companies taking part in this project are the Montana Power Company, Butte,

Montana ; the Washington Water Power Company, Spokane, Washington ; the Pacific Power and Light Company, Portland, Oregon ; the Portland General Electric Company, Portland, Oregon, and the Mountain States Power Company, Albany, Oregon.

Finally, the A.E.C. announced that it has made available to the public on a limited basis the specialised facilities of the Materials Testing Reactor at the National Reactor Testing Station in Idaho. The "MTR," which was developed and built by the Reactor Development Division of the A.E.C., is a unique research tool because it is a high-intensity neutron source. It can produce isotopes of higher specific radio-activity than the Argonne, Brookhaven and Oak Ridge reactors, where irradiation services are also performed for the public. The "MTR" was designed and constructed as an important step in the development of high-neutron intensity reactors, and with the primary purpose of providing facilities to test materials which would be used in future reactor construction, and it continues to serve this purpose. A part of the reactor space made available to the public on a continuing basis will provide a higher neutron intensity than is available at present in other reactors. Even portions of the area of the greatest neutron intensity of the pile, which is used primarily for A.E.C. projects, may be available to the public from time to time. Requirements of the atomic energy programme will take precedence over non-government experiments in all areas of the reactor, and because of security considerations experiments requested by the public will be performed by the contractor who operates the reactor for the Commission.

Heat-Resistant Vacuum Valve

A heat-resistant, hard-glass vacuum valve designed to withstand the high thermal environment and extreme stress conditions in military and commercial aircraft, has been developed by the Red Bank division of the Bendix Aviation Corporation, Eatontown, New Jersey. The heat-resistant "6AQ5" valve has an envelope of "Nonex" glass and will operate at a bulb temperature of 572 deg. Fah. for a minimum of 1000 hours. It is believed that the new valve will help to lengthen the life span of the ever-increasing number of automatic systems being installed to control the many phases of modern flight at high speeds and altitudes.

According to the company, the present high incidence of valve fatigue failures is due to structural weaknesses and to operation at temperatures above the maximum permissible at peak operational loads. It has been found that in the past most failures resulted from the following conditions :—(1) H.K. (heater-to-cathode) shorts and open heaters due to the folded heater design being prone to chipping at the ends and due to electrolytic failure of the coating. Failures of the heater weld also occurred due to an unprotected weld between the tungsten filament and the nickel stem lead. (2) Open tabs occurring on the cathode and the grid due to crystalline failure when the assembly was subjected to resonant frequencies. (3) Sawing of mica components by unanchored supports. (4) Destruction of mica points due to a weakness of the mounts in a plane perpendicular to that of the side rods. To overcome these shortcomings of the conventional valves research conducted on the new unit included fatigue tests run on a specially constructed shake table which subjected the valves to a repeated shock of about 200 g. at a frequency of approximately 18 c/s. A conventional wireless valve lasts from ten to twenty hours under this test. The new valve was found to withstand a 200-hour test under the same conditions, which are believed to be equivalent to 3000–5000 hours of actual flight conditions.

The mechanical criteria established as a result of this research work on the valve called for heavy mica components with many points contacting the glass ; a circular button stem with integral mount supports to yield a box-like structure with strength in any direction and with as many welds as possible eliminated ; additional mica placed at the top of the valve to prevent barium splash leakage ; larger grid side rods and supports ; increased K-to-G (cathode-to-control grid) spacing in triodes and pentodes and K-to-A (cathode-to-anode) spacing in rectifiers, and the use of a snubbing tab on top of the cathode to reduce resonance. The electrical standards adopted included the use of larger cathode areas to reduce the current density ; larger anode areas to reduce the overheating of parts ; gold-plated molybdenum laterals to prevent primary and secondary emissions from the grid ; additional getters to obtain an improved vacuum ; heavy current activation to out-gas the electrodes, and a forty-five-hour ageing cycle under vibration to stabilise the valve characteristics. The high temperatures required to mould the "Nonex" glass presented a special problem as the conventional lead-in wires melted before they could be sealed into the base of the valve. Tungsten therefore had to be used as the material for the lead-in wires in these valves. To overcome the oxidation of the tungsten, the pins were gold-plated. In addition, the wires were made in one continuous length to obtain additional strength and to avoid the high amount of breakage which had occurred previously in welded wires. A further improvement resulted from the replacement of standard mica spacers with ceramic units. It was found that in the out-gassing operation the extreme heat needed to seal the tube "squeezed" moisture from the mica and created a harmful vapour. However, ceramic spacers do not exude this moisture under the high-temperature conditions needed to seal the hard-glass envelope.

Diesel-Electric Generating Plant in Chile

The new power station of the Anglo-Lautaro Nitrate Corporation at Coya Sur, Chile, which recently went into operation, employs two of the most powerful single-acting, two-cycle diesel engines ever built in the United States. The engines are each rated 9600 *b.h.p. at sea level and drive* 8750*kVA, three phase,* 60 *c/s. a.c. generators. The extensive use of remote controls and the high recovery of waste heat are interesting aspects of this installation.*

THE Anglo-Lautaro Nitrate Corporation, of Chile, recently completed the construction of a power station comprising two 9600 b.h.p. vertical, twelve cylinder in-line diesel engines made by the Nordberg Manufacturing Company, of Milwaukee, Wisconsin, and two 8750kVA generators made by the General Electric Company, of Schenectady, New York. The power plant now forms part of a three-station grid operated by the company, which has a combined power generating capacity of 46MW. The new plant was designed and built by the Engineering and Construction Departments of the Anglo-Lautaro Nitrate Corporation. The operations of this company cover a large area in the Chilean nitrate fields inland from Tocopilla and Antofagasta, with two equally large nitrate producing plants being situated at Maria Elena Pedro de Valdivia. In addition to the plants engaged in the production of nitrate, the company owns and operates a 100 miles long partially electrified railway between the plants and the port works at Tocopilla.

Early in 1951 the operations of these plants were found to be hampered due to a difficult power situation. As a result of the completion of a solar evaporation plant at Coya Sur and the electrification of the railway from Maria Elena to a new mining area, the plants were forced to operate without any reserve power. Under these circumstances it was impossible to expand or to electrify further the ore haulage system. It was necessary, therefore, to install additional power generating plant in order to go ahead with plans for the expansion of production facilities. It was decided to install the additional power generating capacity at the Coya Sur site, as that area is now and probably

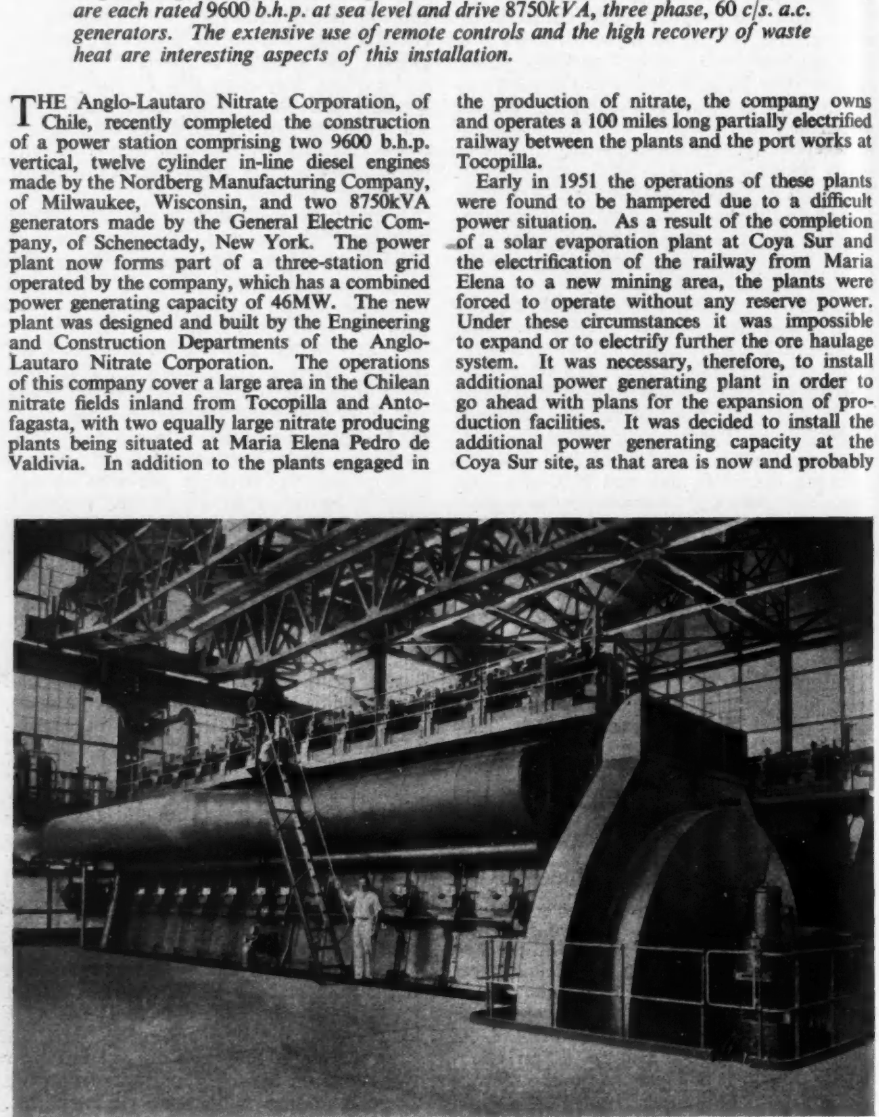
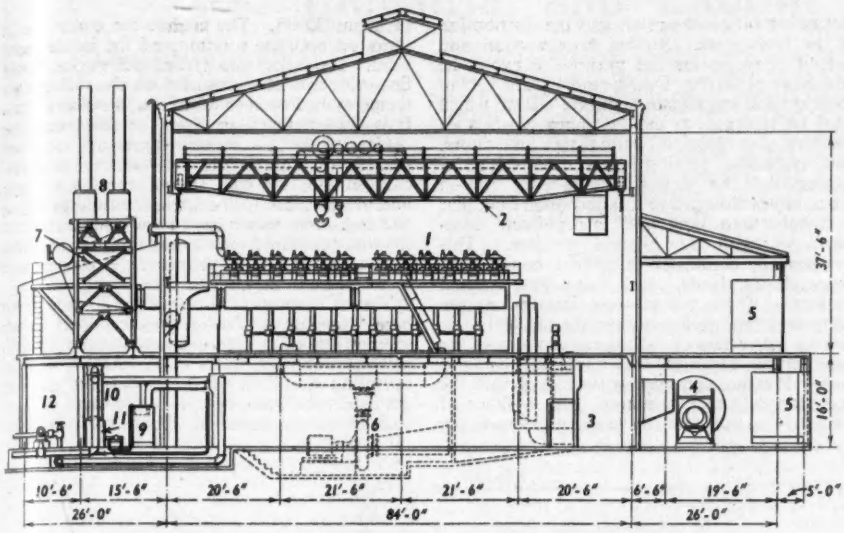


Fig. 1—Nordberg 9600 b.h.p., two cycle, vertical, twelve cylinder in-line diesel engine at Coya Sur power station



1. Engine.
2. 50-ton crane.
3. Plenum chamber.
4. Air washer fan.
5. Air washer.
6. Scavenging blower.
7. Waste heat boiler.
8. Silencer.
9. Lubricating oil sump tank.
10. Lubricating oil cooler.
11. Lubricating oil filter.
12. Jacket water pump.

Fig. 2—Sectional elevation of Coya Sur power station

will continue to be for the life of these properties, the centre of the load of the entire electrical system. It was felt that the construction of a new plant in this area would result in economies from the standpoint of line losses as well as facilitate the distribution of power in the most efficient manner. As it is possible that the installations of the solar evaporation plant might be extended in the near future and that other by-product plants will be constructed in this same area, it was considered to be very convenient to have not only a nearby power source, but also waste heat that can be used in the form of hot water or steam. Once the company had decided upon the amount of additional power required and the site of the proposed new power station, it consulted the Nordberg Manufacturing Company for suggestions concerning the layout of the new plant.

The two Nordberg engines now installed at Coya Sur (Fig. 1) are each rated at 9600 b.h.p. at sea level, corresponding to 8950 b.h.p. at the 4166ft elevation at Coya Sur, when operating at 171 r.p.m. The usual margin of 10 per cent overload for two hours in any twenty-four-hour period has been retained in this rating. The engines are vertical, two cycle, crosshead units with mechanical injection. Each has twelve cylinders in-line of 29in diameter and 40in stroke. The mechanical rating of 8950 b.h.p. and the electrical rating of 6400kW at 80 per cent p.f. are net capacities after deducting the power required to drive the motor-driven scavenging blower. The power input to the motor driving the blower is about 545kW when the engine is operating at full load. The General Electric generators are totally enclosed and forced-air ventilated and are rated at 8750kVA or 7000kW at 80 per cent p.f. They generate three phase, 60 c/s. a.c. current at 6·6kV and have vee-belt-driven exciters rated 250V, 300A at 850 r.p.m.

Engine Building

The steel structures to house the engines and their auxiliaries (Fig. 2) were designed and detailed in the company's own drawing offices. The completed drawings were sent to the Bethlehem Steel Corporation at Bethlehem, Pennsylvania, where the structural steel for the buildings was fabricated. The main engine-room is 84ft wide by 108ft long. Along the east wall of the engine-room a gallery at engine operating platform level provides space for a walkway between the engines and the fuel oil heating and filtering units. The starting air bottles are also situated along the east wall on concrete pads with their head ends passing through openings in the gallery floor. The concrete foundations for the engines were poured to a height a few feet below the engine-room floor level so as to have the top of the engine bed-plates flush with the floor. The bed-plates, which are in two halves, are not grouted and bolted directly to the foundations in the usual manner. Instead, they rest on shims which, in turn, rest on the machined surfaces of cast iron box girders concreted into the foundations and running the full length of the engines. These girders have eight cast-in chocks on each side of the engines to wedge in the bed-plates against any horizontal side movements. This special method of construction was necessary because of frequent seismical movements in the area which may cause a misalignment of the bed-plate sections.

Cool air for the engine-room is supplied through grilled openings in the floor. This air is discharged from the building through louvre vents in the monitor which runs the full length of the roof, thus providing ample movement of the air to remove the vapours emanating from the engine-room. A track entrance has been provided at engine-room floor level by means of an approach trestle. This entrance is used for supplies and heavy pieces of machinery which must be transported by rail. When the track is not in use, a large rolling door is pulled down to close off the opening against heat and dust.

A full-width glass partition separates the air-conditioned control room lean-to from the main engine-room. In addition to the standard control room equipment (Fig. 3) found in modern diesel-electric generating plants, special gauge boards and control panels have been installed for each engine on which are mounted all engine gauges, remote controls for starting, loading and stopping the engine; blower motor controls and push-button stations for all auxiliaries. A special resistance thermometer has been provided to indicate the temperatures of lubricating oil and jacket water at twenty-eight points along the flow to and from the engine. An exhaust pyrometer indicating the temperature of each cylinder is mounted on the control panel, together with an engine alarm system to indicate by howler and lamps any excessive temperature and/or low pressure of the engine jacket water and lubricating oil.

On the same floor and adjoining the control room is the air washer lean-to. The air washers and air washer blower fans have been installed in duplicate for emergency use in case of failure and to facilitate maintenance. The air washers are mounted one above the other on different floors and two are required for each fan. The air washers are of the centrifugal spray design with louvre intakes to the outside of the building and eliminators on the fan side. The four air washers were furnished by the American Blower Corporation and have a capacity of 75,000 c.f.m. of air at 70 deg. Fah. each. Each one of the two 152,500 c.f.m. heavy-duty fans is equipped with shutters on the discharge side so that either fan may operate while the other is not in use. The air from these fans provides the ventilation for the generators through the plenum chamber and serves as the intake air for the scavenging blower. These fans also supply the ventilation to the main engine-room, the auxiliary equipment room and the control room through ducts connecting to the plenum chamber.

Fuel Oil System

Two different grades of fuel oil are used for this installation. Their physical characteristics are given in the table overleaf.

A considerable amount of foreign material is found in the fuel, principally because it is

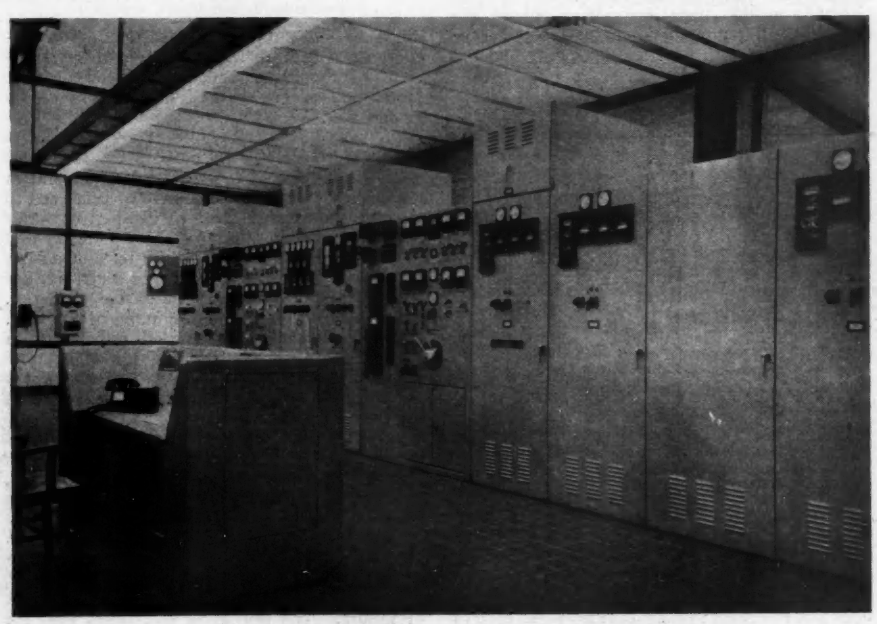


Fig. 3—Control room of Coya Sur power station

transported from the seaport to the plant in a fleet of tank wagons which also are used to transport "Bunker C" oil. Although the fuel oil is heated and centrifuged, sufficient foreign material passes through to make additional filtering necessary before the fuel enters the engine in order to minimise wear on the fuel pumps and injection valves. A 5000-ton capacity all-welded fuel oil storage tank receives the incoming fuel from the tank wagons. From the storage tank the fuel is drawn off by pumps as required through a steam heater, situated adjacent to the tank. The heated fuel is then pumped through an "Auto-Klean" edge filter and then into another steam heater which is thermostatically controlled to maintain a constant temperature for centrifuging.

Six De Laval centrifuges are installed at the power station in two groups; two are in the first group and four in the other. The units in the first group are used as separators and are installed upon a platform above the level of the second group which are used as clarifiers. The difference in levels makes it possible to feed the clarifiers by gravity from the discharge of the separators. The discharge from the clarifiers also flows by gravity into a sump tank. The sump tank is equipped with level controls which automatically actuate the pumps that deliver the cleaned fuel oil to the service tanks situated on a terrace outside of the main engine-room. Although the static head provided by the elevated service tanks amounts to about 20 lb per square inch, booster pumps were installed between the service tanks and the Nugent filters to increase the pressure to 30 lb per square inch to ensure adequate circulation when using the heavier of the two fuels mentioned above. Electric heaters were also installed for service when using the heavier fuel to raise the fuel temperature from 10 deg. Cent. to 50 deg. Cent. before going into the Bosch fuel pumps on the engine. The filters, heaters and fuel oil booster pumps are all situated on the operating gallery behind the engines. All piping between these units is of copper tubing with high melting point soldered joints being employed.

Fuel Oil Data

	"Talara" oil	"Stanship" oil
Specific gravity at 60 deg. Fah.	0·890	0·916
Beaumé Number at 60 deg. Fah.	27·5	23
Viscosity at 122 deg. Fah., Saybolt Universal Units	76	60
Flash point	180 deg. Fah.	150 deg. Fah.
Fire point	240 deg. Fah.	—
Carbon residue (Conradson) ...	2·01 per cent	0·1 per cent
Ash	0·03 per cent	0·02 per cent
Sulphur	0·23 per cent	1·25 per cent
Asphalt, soft	0·42 per cent	—
Asphalt, hard	0·16 per cent	—

Lubricating Oil System

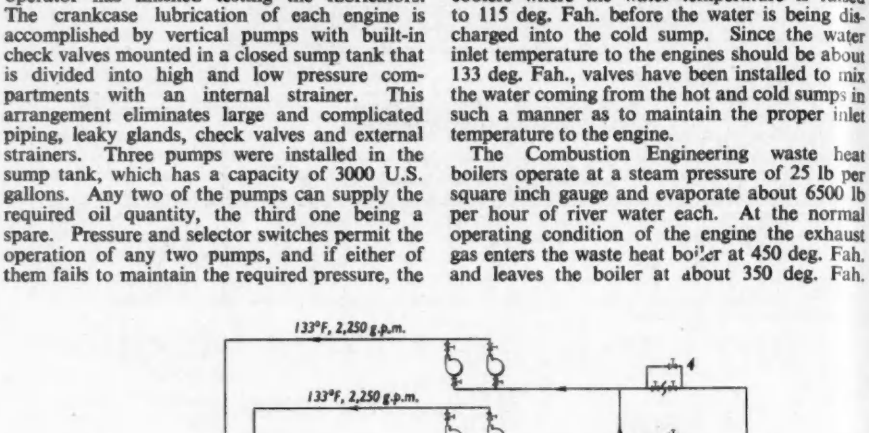
Forced feed lubricators with seven separate pumps and feeds for each cylinder supply lubricating oil to the cylinder liners of the engines. The reservoirs of these lubricators are normally filled by an attendant while making routine inspections of the lubricators and other parts of the engine. Since this power plant is designed to operate with only the switchboard operator and an assistant, a system for maintaining a constant level in the reservoirs of the lubricators has been developed, allowing the assistant switchboard operator to make only one inspection trip per shift around the lubricators to see that they are functioning properly.

The lubricating oil storage tank was placed in the basement and was equipped with remote level indication on the control desk. From this tank, lubricating oil is pumped in a closed circuit to a small tank mounted on the wall behind each engine. The level in the wall mounted tank is identical with that of the individual lubricator reservoirs. A header connecting all lubricators on one engine with the constant level tank passes beneath the floor and has risers to each lubricator. In each of the risers is placed a short section of "Neoprene" rubber hose which can be pinched shut for testing oil consumption and the distribution of the lubricators. Rubber hose was selected instead of valves for this purpose to avoid the possibility of leaving a valve closed. The rubber hose system employs one pinch clamp which must be returned to the switchboard when an operator has finished testing the lubricators. The crankcase lubrication of each engine is accomplished by vertical pumps with built-in check valves mounted in a closed sump tank that is divided into high and low pressure compartments with an internal strainer. This arrangement eliminates large and complicated piping, leaky glands, check valves and external strainers. Three pumps were installed in the sump tank, which has a capacity of 3000 U.S. gallons. Any two of the pumps can supply the required oil quantity, the third one being a spare. Pressure and selector switches permit the operation of any two pumps, and if either of them fails to maintain the required pressure, the idle pump is automatically started. The discharge piping from the high pressure compartment of the sump tank runs directly to the lubricating oil coolers and then returns to the engine inlet.

Cooling Water System

The heat rejected to the jacket water and in the exhaust gases are the sources of heat used to concentrate solutions and to distil river water used as make-up water for the cooling system of the engines (Fig. 4). The heat reclaimed from the jacket water is over twice as much as that reclaimed from the exhaust gases and, therefore, more important from the standpoint of recovery. The jacket water cooling system differs from a closed system only by the addition of hot and cold sump tanks of 1000 tons capacity which are open to the atmosphere. The purpose of the tanks is to provide a larger body of cooling water than that available with the entirely closed system and a more even water temperature which is easier to control. Instead of cooling towers, this system employs heat exchangers in which processing solutions are heated by the jacket water. Water leaves the engine at about 145 deg. Fah. through a pipe which is elevated to a level slightly higher than that of the engine, to prevent the draining of the jackets in cases of failure. The hot water discharges into the hot sump from which it flows by gravity to the jacket water heat exchangers through a distance of about 2000ft. The coolers are connected in series on both the solution and the jacket water sides. The jacket water from each engine passes first through five coolers which reduce the temperature from 145 deg. Fah. to 105 deg. Fah. It is then pumped back to the lubricating oil coolers where the water temperature is raised to 115 deg. Fah. before the water is being discharged into the cold sump. Since the water inlet temperature to the engines should be about 133 deg. Fah., valves have been installed to mix the water coming from the hot and cold sumps in such a manner as to maintain the proper inlet temperature to the engine.

The Combustion Engineering waste heat boilers operate at a steam pressure of 25 lb per square inch gauge and evaporate about 6500 lb per hour of river water each. At the normal operating condition of the engine the exhaust gas enters the waste heat boiler at 450 deg. Fah. and leaves the boiler at about 350 deg. Fah.



1. Engines.
2. Circulating jacket water pumps.
3. Hot jacket water sump tank.
4. Sylphon temperature regulating valve.
5. Cold jacket water sump tank.
6. Lubricating oil coolers.
7. Cold jacket water return pump.
8. Jacket water coolers.
9. Vertical solution pumps.
10. Solution evaporating ponds.

Fig. 4—Cooling system flow diagram, Coya Sur power station

The steam generated is used principally as distilled make-up water for the engines and the air washer system. In addition to a distilling plant steam heat exchangers are installed at the power station and may be used for the further heating of processing solutions.

Tripod Dome

An unusual building is now under construction at the Massachusetts Institute of Technology, consisting of two auditoria, the principal one seating 1200 persons. The structure of this building comprises a dome forming an equilateral spherical triangle corresponding to one-eighth of the surface of a sphere, carried on three supports—one at each corner of the triangle—which are spaced 160ft apart. The dome has a radius of 112ft near the centre, which is reduced to about 90ft near the supports to gain headroom. The maximum clear height above the main auditorium is about 45ft and the three "spandrel" walls are of glass. The concrete shell of the dome has an average thickness of 4·8in, including the haunches and edge stiffening beams, the thickness varying from 3½in to 5½in. Over this dome there is a layer of 2in of rigid insulation, a second layer of concrete 2in thick, and lead-covered copper roofing. These outer layers are provided solely to improve the acoustic properties of the auditorium.

Industrial and Labour Notes

Changes in Wage Rates

The Ministry of Labour states that changes in wage rates which came into operation during May resulted in an aggregate increase of about £481,000 in the weekly full-time wages of 1,909,000 workpeople. Among those receiving increases were workers in building and civil engineering contracting, the iron and steel industry, electricity supply, gas supply, heating and ventilating engineering, and cement manufacture.

In building and civil engineering contracting in Great Britain, there was an increase of 1½d. an hour for adult male workers ; manual workers in the electricity supply industry received an increase of 1d. an hour in the schedule rates, and adult male workers in the gas industry received an addition of 1½d. an hour to their scheduled rates, gas works maintenance craftsmen receiving an additional 2½d. an hour. In heating and ventilating engineering, the wage increase was 1½d. an hour for craftsmen and adult mates, and in the cement manufacturing industry there was an increase of 1¾d. an hour for adult male workers other than maintenance craftsmen and transport workers. In the iron and steel industry, there were small increases payable under sliding scale arrangements based on the index of retail prices.

The Ministry of Labour says that in the first five completed months of this year, changes in wage rates have meant an aggregate increase of £2,135,800 in the weekly full-time wages of 6,543,500 workpeople. In the corresponding months of last year there was a net increase of £1,094,000 in the weekly full-time wages of 3,945,000 workpeople. At the end of May this year the index of rates of wages (June 30, 1947=100) stood at 142 for all workers. This was one point higher than at the end of April.

Labour Charges

At the annual general meeting of Siemens Brothers and Co., Ltd., which was held in London last week, the chairman, General Sir William Morgan, commented in his address on the effect of labour charges. Those charges, he said, predominated in the cost of many of the firm's products. The effects, particularly in competing for orders abroad, were felt during 1953, and would be felt more in the current year in view of further awards recently granted.

Though in certain cases, Sir William continued, allowance was made by customers for increased labour costs, that seldom applied to markets where the greatest competition existed. Orders often had to be taken on a firm-price basis, regardless of wage and salary increases which took place between the receipt and completion of an order. Even where allowance was made, there must inevitably be a diminution of orders to conform to "spending ceilings." A serious consequence of that, Sir William added, was decreased turnover in face of overhead charges which, failing increased productivity, could not be reduced proportionately.

Sir William went on to refer to the various efforts which his company was making to offset the effects of the increases. But, he said, salutary as those efforts were proving, the fact remained that there was a limit beyond which costs must not rise if the requisite volume of business was to be secured. In his view, that limit had already been reached, and, in relation to recent foreign competition, he thought that it had been exceeded.

Trade Disputes

According to statistics published in the *Ministry of Labour Gazette*, the number of stoppages of work through industrial disputes in the United Kingdom, which were reported as beginning during May, was 187. In addition, fourteen stoppages which had begun earlier were still in progress in May. In these 201 stoppages of work, 28,200 workpeople were involved directly and indirectly during the month, the aggregate number of working days lost being 112,000. Most of the stoppages were in the coal mining industry, where 41,000 working days were lost during May by 17,300 workers. The Ministry's figures show that in the first five months of this year, there were 896 stoppages of work through disputes. They affected 182,700 workers and caused an aggregate loss of 621,000 working days. In the comparable period of last year, the number of stoppages reported was 717. They resulted in an aggregate loss of 587,000 working days by 120,400 workers.

Coal Production

Some forthright comments about the coal situation in this country are made in the report which the executive of the National Union of Mineworkers is to present at the union's annual conference next week. The report recalls the decision taken by the union and the National Coal Board early this year that during 1954 a 2½ per cent increase in coal production would be reasonable. It goes on to say that up till May output had increased by only 0·2 per cent, which the union executive describes as disappointing. The fact must be faced, the report continues, that the industry can be placed in a very serious position unless means are found to create again an upward trend in production in order to keep pace with the continued increasing demand.

The executive emphasises the need for building up coal stocks to about 20,000,000 tons by the end of October, and comments that even if another 100,000 tons of coal a week are produced during the summer period, the industry may still be faced by the end of October with a deficit of something in the region of 1,500,000 tons. Unless, therefore, there is a considerable improvement in output, the report goes on, "we may find the industry in a position which, in the interests of all concerned, must be avoided. It would be a tragedy if we found ourselves faced with the dilemma of having either to cut exports or to import large quantities of foreign coal. Any action on these lines would be detrimental not only to the Coal Board and to the union but to the country as a whole, and we and the board must do everything possible to prevent such a situation developing."

Figures issued by the Ministry of Fuel and Power on Wednesday morning show that last week's output of deep-mined coal was 4,211,800 tons, and of opencast 239,400 tons, making a total of 4,451,200 tons. In the first twenty-five weeks of this year, ended June 26th, the quantity of coal produced was 111,751,200 tons, compared with 110,694,400 tons in the corresponding period of last year.

German Trade and Production

In the latest issue of *Bulletin for Industry*, which is a review of the economic situation prepared by the Treasury, a survey is made of present trends in Western Germany's trade and production. This survey says that Germany's overseas trade position has improved every year since 1949. In 1953 her exports exceeded imports by about £305 million, and when a small surplus on invisible transactions is added, Germany's current surplus with the rest of the world, excluding aid, was about £310 million (compared with the United Kingdom figure of £123 million).

The survey suggests that the increase in German exports was to be expected, but that in relation to pre-war years the figure for 1953 does not seem so large. Germany's share in world trade is still smaller than before the war and last year was about 14 per cent, compared with 24 per cent for all Germany in 1937. But it is pointed out that whilst the value of Germany's exports has more than doubled since 1950, the value of her imports has risen only by about one-third. This surplus of exports over imports, it is stated, still seems to be growing. In the first four months of this year the monthly average of exports was 7 per cent above the monthly average for the whole of last year, but imports were less than 1 per cent higher. The survey goes on to show that the improvement in Germany's overseas position has been backed by a considerable increase in production, although last year the increase was no longer far ahead of that of other O.E.E.C. countries. In mining and manufacturing last year, Germany's production was 7 per cent higher than in 1952 ; the comparable figures for the United Kingdom and for Western Europe as a whole being 6 per cent.

The survey explains that German industry has had a considerable reserve of labour on which to draw to help this increase in production. Between 1948 and 1953 the increase in civil employment in the United Kingdom was 3 per cent ; in Germany it was 16 per cent. Refugees from the Eastern zone have increased Western Germany's labour force year by year, and even now there is considerable unemployment, the unemployment figure averaging 1,250,000 during 1953. Rather longer hours are worked in Germany, the figure for manufacturing and building being 47·9 hours a week, compared with 45·9 hours a week in manufacturing industry in this country. Hourly earnings in manufacturing industry in Germany have risen every year since 1948. Between 1950 and 1953 earnings in the manufacturing industries in Germany and the United Kingdom rose by 7d. an hour. The survey adds, however, that these figures for money earnings are put in a rather different light when compared with the movement of retail prices. With 1950=100, the index of all retail prices in Germany in 1953 stood at 108, compared with 123 in the United Kingdom. From this comparison it is deduced that, whilst between 1950 and 1953 real hourly earnings in this country rose only slightly, in Germany they rose by one-fifth, which corresponds, the *Bulletin* says, "to a much greater increase in output per man in Germany than here."

Education and Training for Management

Some months ago, the British Institute of Management published a booklet entitled *Education and Training in the Field of Management*, which gave details of the work being done by technical colleges in this country in management education and training. The Institute has now produced a second volume under the same title. This one surveys short courses, of up to three months' duration, which are organised by thirty-nine university extra-mural departments, professional and educational bodies, and residential establishments. The information contained in this volume shows that in recent years the universities have increased their participation in management education, and that there is also now a growing preference for courses shorter than the conventional one-year post-graduate courses at universities and technical colleges. The new volume, which costs 3s. 6d., is available from the British Institute of Management, 8, Hill Street, London, W.1.

Accident Prevention in the Cement Industry

In 1950, the Cement Makers' Federation established an accident prevention advisory committee, which consists of representatives of its member firms. Its functions include the pooling and distribution of information on the many phases of accident prevention, examining accident statistics, watching tendencies, and offering advice wherever it is thought it would be of value in decreasing the kinds of accidents which occur.

The fourth annual report of the committee records four fatal accidents in 1953, the total number of accidents during the year being 433, which was three more than in 1952. The report says that, as in the two preceding years, the accidents which may be grouped under the general heading of "tripping, slipping, striking and handling," together with those caused by objects falling, were responsible for about 70 per cent of last year's accidents. These accidents, which, the report comments, may too easily be dismissed as unavoidable, could be studied with profit by the individual works. Only about 6 per cent of last year's accidents were caused by machinery, a factor, the committee says, which points to the need for concentrating on safety education in order to overcome human failing.

Notes and Memoranda

Air and Water

LAUNCH OF FAST REPLENISHMENT TANKER.—The fast replenishment tanker, "Tiderange," was launched on July 1st from the yard of Sir James Laing and Sons, Ltd. The ship has a length between perpendiculars of 550ft by 71ft beam, and a deadweight of 17,700 tons.

LAST VOYAGE OF "LLANGIBBY CASTLE."—On Tuesday of this week, the Union Castle liner "Llangibby Castle" sailed from London on her final voyage to the ship breakers. The ship, which was the first motor vessel employed in the company's intermediate service, was built in 1929 at the Govan yard of Harland and Wolff, Ltd.

CONVERSION TO SUBMARINE RESCUE SHIP.—The ocean salvage ship "King Salvor" has been converted to a submarine rescue bell ship and renamed H.M.S. "Kingfisher." The ship, which will be based mainly on the Clyde, has a length of 217ft, a displacement of 1690 tons and a complement of seven officers and seventy-five ratings. The equipment includes the American rescue bell and to make rescues possible by this technique special equipment is built into new submarines.

LAUNCH OF ANTI-AIRCRAFT FRIGATE.—The first of a new design of anti-aircraft frigate, H.M.S. "Puma," was launched on June 30th from the Greenock yard of Scott's Shipbuilding and Engineering Company, Ltd. The ship has an overall length of 340ft, a beam of 40ft, and will carry four 4·5in guns, two small guns and a "Squid" anti-submarine mortar, and will be propelled by Admiralty Standard Range I oil engines, driving through hydraulic couplings and oil-operated reverse and reduction gearboxes.

BRITISH WATERWORKS ASSOCIATION.—The British Waterworks Association is holding its annual meeting and conference at Bournemouth from June 30th to July 2nd. On Wednesday afternoon a paper entitled "Assessing the Value of Cloudseeding Operations to Water Supply," by Mr. I. P. Krick, president of the Water Resources Development Corporation, Denver, Colorado, was presented. On Thursday morning a discussion entitled "Organisation and Methods—its Scope and Limitations," was introduced by Mr. P. S. Milner-Barry.

HAWKER "HUNTER" CLEARED FOR R.A.F. DELIVERY.—The Hawker "Hunter" has now been officially cleared for delivery to the Royal Air Force. Following extensive final flight trials at Boscombe Down, the clearance documents have now been signed. It is in super-priority production for the Royal Air Force in Hawker factories at Kingston and at Squires Gate, Blackpool. In addition to R.A.F. orders, the "Hunter" has been ordered by the Dutch and Belgian Air Forces, and orders amounting to 182 million dollars under the U.S. offshore purchase programme for NATO air forces.

RESCUES BY H.M. COASTGUARD.—The Ministry of Transport and Civil Aviation reports that life-saving apparatus was used by H.M. Coastguard on eighty-three occasions during the year ended March 31st last. The number of persons brought to safety was 118, including sixteen by the use of the breeches buoy. Cases in which life-saving action was taken as a result of vessels or aircraft being observed, or reported to be in distress, numbered 845. The number of vessels which had been seen standing into danger and were warned of their position was fifty-seven. In addition fifty-seven people who had got into difficulties on cliffs, and fifty-eight people who had been cut off by the tide, were assisted to safety.

JET TRANSPORT FOR R.A.F.—The Secretary of State for Air has announced that Vickers-Armstrongs, Ltd., is to receive a production order for the Vickers "V.1000" military transport aircraft for the Royal Air Force. Work is proceeding on the construction of a prototype aircraft to a Ministry of Supply order placed in January, 1953. The machine will be powered by four Rolls-Royce "Conway" by-pass turbo-jet engines. Its approximate dimensions are: wing span, 140ft; length, 146ft; height, 38ft 6in. The aircraft is a low-wing monoplane with a wing similar to that of the "Valiant" bomber, featuring a cranked leading edge. Both mainplane and tailplane are swept back and the engines are completely enclosed in the wings. The "V.1000" will be capable of operating over very long distances at high subsonic speeds.

Miscellanea

PROPORTIONING OIL BURNER.—We have received from The Kingdom Engineering Company, Ltd., of 22, Waterloo Road, Wolverhampton, a copy of a pamphlet which gives the capacity, dimensions and general particulars of the Kingdom proportioning oil burners.

MR. J. L. EVE.—We have learned with regret of the death of Mr. John Leonard Eve, M.I.C.E., M.I.E.E., which occurred at Wimbledon, London, S.W.19, on Friday last, June 25th. Mr. Eve was chairman and managing director of J. L. Eve Construction Company, Ltd.

CONDENSER TUBES.—A new publication of the I.C.I. Metals Division deals in detail with the firm's wrought non-ferrous metals used in steam condensing plant and in particular with condenser tubes. The various kinds of tubes made by the firm, and their applications, are described, followed by notes on condenser tubes in service, their corrosion resistance, forms of attack, fitting and care.

BURSARIES IN CONCRETE TECHNOLOGY AT UNIVERSITY OF LEEDS.—Applications have been invited for bursaries in concrete technology tenable from October, 1954, at Leeds University, valued at £350 per annum, out of which the University fees have to be paid. They will be awarded for one year and may in certain circumstances be renewed for a second year.

ENGINEERING EMPLOYMENT IN SWEDEN.—It is reported that employment in the Swedish engineering and shipbuilding industries increased by 0·78 per cent in April and was 2·2 per cent higher than in the comparable month of 1953. The total number of working hours recorded was 9,130,000, against 9,050,000 in March. The highest single increase in employment in April occurred in the shipbuilding industry.

ALUMINIUM BUILDING SHEET.—"T. I. Aluminium Building Sheet" is the title of a booklet, recently published by T. I. Aluminium, Ltd., which discusses the types and sizes of the sheet, produced by the company, together with methods of fastening. Details such as the maximum distributed load per square foot in association with purlin spacing are given and tables record the weights of different forms of sheet over a range of lengths.

MACHINE TOOL SHOWROOMS.—On Tuesday, July 13th, a new showroom for machine tools is being opened by M. C. Layton, Ltd., at Abbey Wharf, Mount Pleasant, Alperton, near Wembley, Middlesex. This showroom has an area of some 9000 square feet and is designed to provide on exhibition lines a comprehensive display of the modern machine tools which the company distributes. Facilities are being provided for demonstrating the machines in operation, and in the future the firm proposes to hold at regular intervals demonstrations of special machines.

NORTH OF SCOTLAND HYDRO-ELECTRIC BOARD.—The first generator of the North of Scotland Hydro-Electric Board's Luichart power station in Ross-shire turned round for the first time on Tuesday, June 22nd. The generator, which has a capacity of 12MW, has still to undergo extensive tests before it is in full operation. A second generator in the station, of the same capacity, is nearing completion. The Luichart station is one of four power stations in the Glascarnoch-Luichart-Torr Achilty scheme, the main development of the hydro-electric resources of the River Conon valley, which will have a total capacity of about 65MW and an output of about 290 million units of electricity per annum.

TUNGSTEN CARBIDE FACTORY IN SWEDEN.—A new tungsten carbide factory built in Stockholm for the Sandvik Steel Company, stated to be one of the largest of its kind in the world, is expected to have an annual output of more than 90 tons a year. The Sandvik organisation carries out all the phases in the manufacture of tungsten carbide from the mining of the high-grade wolfram ore to flaking the finished product. This new plant will supply the firm's factories in Sweden, South Africa and Canada with tungsten carbide inserts for drill steels, cutters, &c. The bulk of these inserts are used for making Sandvik "Coromant" drill steels, which are marketed by the Atlas Diesel Company.

TURBINE LUBRICATING OIL PURIFICATION.—A technical report has just been published by Sharples Centrifuges, Ltd., Tower House, Woodchester, Stroud, Glos, on methods for the continuous purification of oil in steam turbine lubricating oil systems. This report has been written specifically for the design and operating engineers of steam turbine plants. It deals with the nature and causes of lubricating oil deterioration in turbine systems, and the methods of avoiding and combating such deterioration. Other sections of the report are designed to be of use to engineers specifying purification equipment for steam turbine plant, and cover such topics as the selection of purifier capacity, design of purification system oil heaters, and the mechanical characteristics of centrifugal purifiers.

SALES OF ELECTRICITY BY THE BRITISH ELECTRICITY AUTHORITY.—Statistics published by the British Electricity Authority show the number of units sold by the Authority and the number of units sent out by the Area Boards, in May, 1954. The overall figures for that month show an increase of 14·8 per cent over those for May, 1953; but when corrections are made for weather conditions and for the number of working days in the month, to make the figures comparable, the increase becomes 9·6 per cent. Among the Area Boards the greatest increases (uncorrected) for the same two months were recorded by South Wales (23·2 per cent), South Western (21·9 per cent), London (17·8 per cent), Merseyside and North Wales (17 per cent), and South Eastern (16·1 per cent).

PLASTICS EXHIBITION.—We are informed by Bakelite, Ltd., that an exhibition of "Bakelite," "Warerite" and "Vybak" plastics will be held at the Bowchier Hall, Institution for the Blind, Newport Road, Cardiff, from Tuesday, July 6, to Saturday, July 10, 1954. At this exhibition there will be demonstrated the many different ways in which the plastics are developed from their basic resinous state, and their wide range of application in industry. Amongst the latest developments in plastics which will also be on show will be glass-reinforced plastics for the production of all kinds of structures from shatterproof, translucent roof sheeting to crash helmets and motor-car bodies; non-corroding, rigid p.v.c. sheet for the construction of chemical plant, and the shell moulding method of making foundry moulds.

ROYAL DESIGNERS FOR INDUSTRY.—The council of the Royal Society of Arts has made the following new appointments to the Distinction of Royal Designer for Industry (R.D.I.): Mr. William Lyons (motor-car design), and Mr. Pinin Farina (motor-body design), Honorary Award. Mr. Lyons is chairman and managing director of Jaguar Cars, Ltd., and Mr. Farina has been responsible for many of the outstanding designs of coachwork for Italian cars since the war. The distinction of R.D.I. was established in 1936 by the Royal Society of Arts as the highest honour to be obtained by industrial designers. The number of living recipients is limited to forty and there are now thirty-eight, including the latest addition. Honorary awards are conferred on foreign designers, of whom ten, with the new recipient, at present hold the honour.

ELECTRIC POWER FOR OUTER HEBRIDES.—The North of Scotland Hydro-Electric Board announces the laying of a submarine cable to bring electricity to the island of Eriskay from South Uist in the Outer Hebrides. The cable has been completed between Saltavik, South Uist, and Rudha Ban on Eriskay. Electricity for the island will be provided from the Board's diesel generating station which is under construction at Daliburgh in South Uist. Survey work on the routes of the distribution lines on Eriskay has been completed and the next stage will be to erect the lines. On South Uist, survey work has been completed and the construction of lines northwards from Daliburgh has begun. The contractor is James Scott and Co. (Electrical Engineers), Ltd., the consulting engineers being Messrs. Merz and McLellan.

NEW AIR SERVICES APPROVED.—The Minister of Transport and Civil Aviation has approved the operation of a number of new air services. The inclusive tour services are between Lympne and Basle until October 31, 1954, operated by Air Kruise (Kent), Ltd.; Southend and Calvi via a technical stop at Lyons, until September 26, 1954, operated by Dan-Air Services, Ltd.; Bovingdon and Basle, until August 22, 1954, and Bovingdon and Munich, until August 29, 1954, operated by Hunting-Clan Air Transport, Ltd., and London (Croydon or Gatwick) and Nice, until September 9, 1954, to be operated by Transair, Ltd. A normal scheduled service London–Frankfurt and/or Dusseldorf and/or Rome–Cairo or Beirut–Khartoum–Entebbe or Nairobi–Salisbury (Kentucky Farm)–Johannesburg is to be operated by British Overseas Airways Corporation until March 31, 1961. Colonial coach class services will be operated by Airwork, Ltd., from London (Blackbushe)–Bathurst–Freetown–Accra, until March 31, 1957, and by Hunting-Clan Air Transport, Ltd., from London (Bovingdon)–Bathurst–Freetown–Accra, until March 31, 1957. An extension to the period of approval of the internal service operated between London (Croydon) and Birmingham (Castle Bromwich) by Olley Air Service, Ltd., to permit operation during the period of the British Industries Fair each year up to and including 1960 has also been approved.

Personal and Business

MR. I. A. MARRIOTT has been appointed a director of Wellworthy, Ltd., Lymington, Hants.

MR. C. K. ANDREWS has been appointed technical manager of Mitchell, Colman and Co., Ltd., Radcliffe, Manchester.

BIRWELCO, Ltd., Chester Street, Aston, Birmingham, states that it is now making, under licence, "Petrochem-Isoflow" furnaces.

MR. M. N. BOYDE has been appointed sales manager of Polygram Casting Company, Ltd., Power Road, Gunnersbury, London, W.4.

THE HUNTING GROUP OF COMPANIES has moved to Norwich House, 4, Dunraven Street, London, W.1 (telephone, Hyde Park 9781).

SIR BERNARD DOCKER has been appointed chairman of Carbodies, Ltd., Coventry. Mr. R. E. Smith has been appointed managing director.

DR. S. WHITEHEAD, director of the Electrical Research Association, has been appointed chairman of the committee of directors of research associations.

THE QUASI-ARC COMPANY, Ltd., Bilston, has opened a new store at the premises of its associated company, Fusarc, Ltd., Team Valley, Gateshead, 11 (telephone, Low Fell 75466).

DUNLOP, Ltd., announces the appointment of Mr. H. Smith, A.M.I.Mech.E., as development engineer for tyres. Mr. M. J. Bartle, A.M.I.E.E., has been appointed overseas factories' engineer.

STANDARD TELEPHONES AND CABLES, Ltd., New Southgate, London, announces the retirement of Mr. W. C. Bennett, purchasing manager, after forty-four years' service. Mr. S. F. Monk has been appointed to succeed him.

B.S.A. TOOLS, Ltd., states that the group branch office in Toronto, at present known as Burton, Griffiths and Co., Ltd., will operate under the name B.S.A. Tools, Ltd., from August 24th. Mr. E. J. Stokes will continue the management of the branch, the address of which is 19, Melinda Street, Toronto, Canada.

THE MINISTRY OF SUPPLY announces that Dr. C. H. Johnson, chief superintendent of the explosives research and development establishment, Waltham Abbey, has been appointed to succeed Mr. C. S. Bryant as director of materials and explosives research and development. Mr. Bryant retired on June 30th. Mr. L. T. D. Williams has been appointed to succeed Dr. Johnson.

THE PLESSEY COMPANY, Ltd., has established a components division at Swindon for the manufacture and sale of electrolytic and paper capacitors and moulded track potentiometers. It will be known as the Swindon Components Division, the address being Kembrey Street, Swindon, Wilts (telephone, Swindon 3461). Mr. O. G. Cox has been appointed general manager.

British Patent Specifications

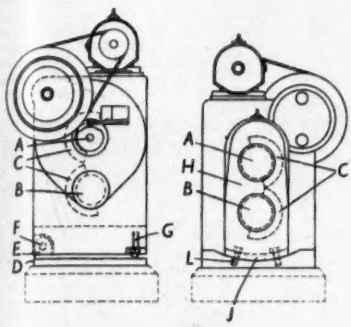
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

MACHINE TOOLS

709,607. July 1, 1952.—ROLLING MILL STANDS, Eumuco Aktiengesellschaft fur Maschinenbau, Leverkusen Schlebusch, Germany.

The invention relates to rolling mill stands for forging and reducing malleable pieces or similar parts, having semi-circular segmental rolls. The object is to arrange the rolls in such a manner that the operator can readily see the groove and can introduce the work in as upright a position as possible



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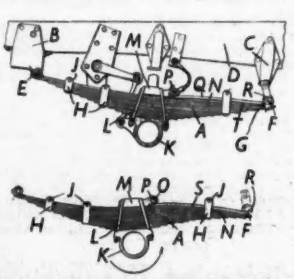
with his outstretched arms. Referring to the drawing, the machine comprises a frame having two standards in which are journalled the rolls. On the rolls *A* and *B* are fixed the roller segments *C* and into the groove between them the work has to be introduced. When the machine is vertical the groove can only be seen with difficulty by the operator, as shown in the left-hand view. According to the invention, the frame of the machine is mounted on the base plate D in such a way that it can be swung or tilted. For this purpose, bearing members *E* are provided at the rear edge of the base plate in which pins *F*, which are fixed to the lower rear edge of the frame, engage. Near the front lower edge of the frame spindles *G* are screwed in and their lower ends are in the form of hexagonal heads having projecting ball-like supporting feet. Instead of supporting the roll frame on the pins in the bearings it may be supported on knife edges resting on bearing surfaces, or, as shown in the right-hand view, the standards *H*, together with their feet *J*, are fixed to the frame in such a manner that they can swing about the axis of the upper roll *A*. After loosening the foot screws *L*, which pass through the slots, the standards can be tilted from the vertical position into a desired inclined position.—*May* 26, 1954.

ROAD TRANSPORT

709,762. December 24, 1951.—LEAF SPRINGS FOR VEHICLES, Vauxhall Motors, Ltd., Bedfordshire. (*Inventors: Roland Ranson Bishop and Maurice Olley.*)

The invention relates to leaf springs for vehicles, both road and rail, the axles of which are subject to torque due to braking and acceleration, and is particularly concerned with the limitation of the distortion of the springs by such torque. In the upper drawing is shown a multi-leaf spring *A* supported



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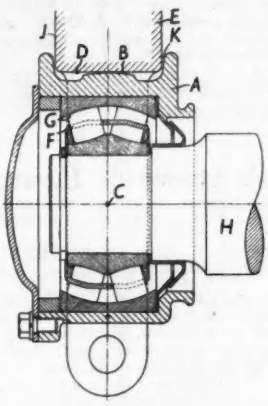
by brackets *B* and *C* from the front end of a longitudinal frame member *D* of a vehicle. The spring is fixed to the bracket *B* by spring pin *E* and to bracket *C* by a shackle and spring pin *F*. The shackle has extended side links *G* to prevent lateral displacement of the adjacent ends of the spring, leaves of which are held together by U-shaped clamps *H* and pins *J*. On the lower side of the spring is an axle block *K* supported by U-bolts *L* which are separated by a spacer *M* on the upper leaf *N*. The U-bolt spacer carries a transverse pin *O* which passes through an eye *P* formed at one end of a stop member or plate *Q*, at the other end of which is a similar eye *R* engaged by the spring pin *F*. The adjacent end of the upper leaf *N* is accordingly flat; it is not attached to the pin *F*, but is held between the stop plate and the adjacent leaf. The stop plate *Q* is stiff and curved convexly upwards so that the adjacent upper leaf *N* contacts with its under surface in the maximum bump position. Under braking conditions, the axle is twisted counterclockwise as shown by the arrow in the lower view, and the axle block *K* and the middle part of the spring *A* is likewise turned such that the upper surface *S* of the upper leaf *N* of that half of the spring, which is bowed upwards, eventually contacts with the under surface of the stop plate Q, whereupon further twisting and wind-up is prevented. Modified designs are also shown in the specification.—*June* 2, 1954.

BEARINGS AND SUPPORTS

703,566. June 20, 1951.—JOURNAL BOX, Aktiebolaget Svenska, Kullagerfabriken, 17, Artillerigatan, Goteberg, Sweden.

The invention is concerned in particular with journal boxes for railway axles. A journal box *A* is provided with a truck frame supporting surface *B*, at the top in the form of a segment of a cylinder struck from a horizontal axis through the centre *C* of the bearing normal to the axis of the journal. The box is provided with integral lugs to limit its angular motion, and to support lateral loads, as its



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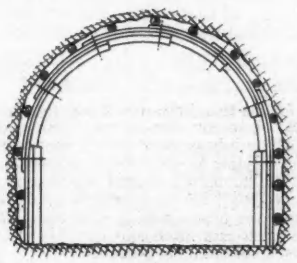
cylindrical surface *B* rocks on a flat surface *D* in the side frame *E*. The box contains a single self-aligning double-row roller bearing *F* having an outer raceway surface *G* of spherical form also centring at *C*. The width of the box is considerably greater than that of the side frame, and the lugs at the sides have a horizontal spread greater than the pedestal opening in the side frame. The lugs are spaced from the walls of the side frame by clearances as shown, which correspond with the amount of rocking resulting when the axle *H* moves from its central to extreme left, or right, position with respect to the side frame. When the axle moves to the left, the inner face of the lug strikes the adjacent wall *J* of the side frame, and the lug strikes the wall *K* when the axle moves to the right. The drawing shows the box in its central vertical position. Several modified designs are also shown in the specification.—*February* 3, 1954.

MINING ENGINEERING

709,672. April 17, 1952.—ARCH SUPPORT CONSTRUCTIONS IN MINES, Karl-Theodor Jasper, Ruhrstrasse 17, Hagen in Westfalia, Germany.

The invention relates to an arch support construction of curved sections of iron beams of the same



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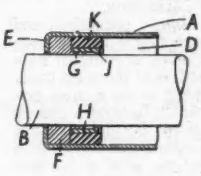
length interconnected in ring shape. These beams interengage lengthwise in roof-tile fashion and are staggered by somewhat more than half their length so that at successive points around the support frame the beams are superimposed as three layers, where they are connected together by stirrups. As shown in the drawing, the lower part of the first and last sections of the construction are straight and are associated with short, straight sections for providing the third section at the first and last stirrups.—*June* 2, 1954.

TUBE AND PIPE CONNECTIONS

710,374. October 18, 1951.—PACKING DEVICES FOR FLUID PRESSURE APPARATUS, Automotive Products Company, Ltd., Tachbrook Road, Leamington Spa, and Levitation, Ltd., 8, The Quadrant, Coventry, formerly of Tachbrook Road, Leamington Spa. (*Inventor: Peter Warborn Thornhill.*)

In the drawing, the packing device is mounted in the end of a cylinder *A* through which projects a sliding rod or stem *B* to prevent leakage of fluid under pressure from the space *D* in the cylinder. The cylinder has an inturned flange *E* against the inner side of which is mounted a metal abutment ring *F* having, on its inner side, an extension *G* in the form of a thin, rigid sleeve. A sleeve-like member *H*, of relatively hard, flexible and resilient material such as Nylon, fitting over the sleeve *G*, is formed at its inner end with an internal circumferential rib *J*, of triangular cross-section, the apex of which bears on the rod. The inner face of the rib *J* is substantially perpendicular to the axis of the packing device, whilst its outer face is inclined. A ring *K* of india-rubber is fitted between the sleeve member *H* and the cylinder wall and extends just beyond the inner end of the member *H*. The ring *K* is compressed on assembly and exerts an inward radial thrust. This inward thrust is augmented by pressure in the space *D*. This inward thrust presses the apex of the rib *J* firmly against the surface of the rod. A modified design is also shown in the specification.—*June* 9, 1954.

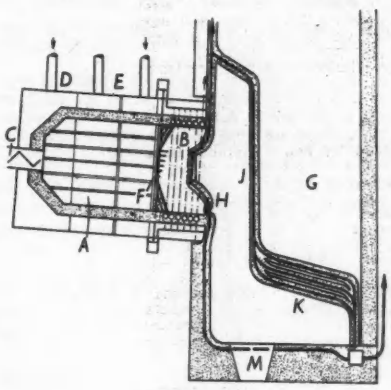


No. 710,374

FURNACES

710,288. October 5, 1951.—PULVERIZED FUEL FURNACE, Steinkohlen-Elektrizitat Aktiengesellschaft, 27 to 37, Rüttenscheider Strasse, Essen, Germany.

The invention relates to furnaces for finely divided fuels, especially pulverised fuels of high ash content. As shown in the drawings, the furnace of the steam generating plant has an elongated and slightly downwardly inclined combustion chamber consisting of two zones *A* and *B*. At the front side of the first zone there is a central inlet *C* for finely divided fuel and primary combustion air. The central inlet sets the fuel-air mixture into rotation, causing the combustion gases to follow a helical path through the two zones. The tubular wall of the combustion chamber is surrounded over the entire length of the



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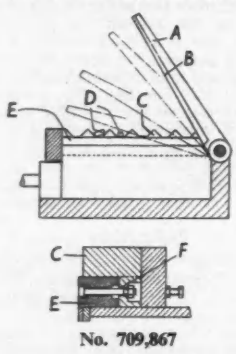
first zone *A* by a closed casing *D* provided with secondary air inlets. Over the length of zone *A* the combustion chamber wall has slot-like apertures *E* through which the secondary combustion air enters from the casing *D* tangentially into the first zone, thereby intensifying the rotation of the combustion gases whilst preventing them from coming into direct contact with the zone wall, which is relatively cool. A partition wall between the zone *A* and the zone *B* of the combustion chamber has several gas passages *F*. These passages intensify the rotation of the combustion gases passing from the zone *A* into the zone *B*. In the peripheral wall of the second zone *B* there are several cooling coils fed with supply water of the steam generating plant. A water cooled wall at the rear side of the zone *B* has a central exit through which the gases pass

into a flue gas chamber *G*. Beneath this gas exit, an outflow *H* is provided in the wall at the lowest point of the combustion chamber. The chamber *G* is divided by a partition wall *J* having gas passages *K*. In the chamber portion adjacent to the gas exit of the combustion chamber, the hot gases are deflected by the partition wall downwards to the bottom of the chamber. The gases rise through the passages *K* into the other portion of the chamber containing a water tube system for steam generating. Solid ash particles carried away with the hot gases are separated by the partition wall *J* and fall on to the bottom of the chamber. The separated particles may be removed therefrom together with the liquid slag dropping from the outflow on to the bottom of the chamber through a bottom aperture *M* into an ash pit.—*June* 9, 1954.

WORKSHOP TOOLS AND APPLIANCES

709,867. July 1, 1952.—SCRAP PACKAGING AND BALING PRESSES, Waldemar Lindemann, Erkratherstr 401, Düsseldorf, Germany.

The invention relates to scrap packeting and baling presses, and more particularly to the construction of the edges of the filling opening of such presses, whereby the cutting action of the press cover is increased. The upper drawing shows a press box having a hinged cover *A* to which is fixed a cutting edge or knife *B*. The edge of the box is of zig-zag form as shown at *C*, which prevents the overhanging material *D* from sliding along the edge of the box when the cover is being closed and collecting on the side of the box opposite the pivot of the cover. The bits of scrap *D* are held by the notches *C* and are



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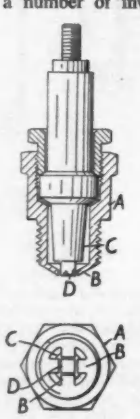
cut off by the knives of the cover. On the inside of the edge of the box are fitted knives *E*, which, as shown in the lower view, are fixed by a clamping bar *F* which has zig-zag or wavy projections. The bar *F* is under-cut so that the part containing the projections is disposed above the knife *E*. The knife and the clamping bar are connected together by bolts and the knife is ground on two sides and can then be changed when worn on one side.—*June* 2, 1954.

INTERNAL COMBUSTION ENGINES

710,198. January 31, 1952.—SPARKING PLUGS, Lodge Plugs, Ltd., St. Peter's Road, Rugby. (*Inventor: Bernard Hopps.*)

The invention has for its primary object the provision of a central electrode in which the effect of erosion is reduced to a minimum. In the drawing the body of the sparking plug, as shown at *A*, has at its outer end a number of inwardly extending



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projections *B* which have rectangular outer end faces and constitute earthed electrodes. The central electrode projecting beyond the usual insulator *C* is shown at *D*, and is of rectangular section with each of its side faces or walls lying parallel to the outer end rectangular face of an earthed electrode, i.e. the gap between each side face of the central electrode *D* and the sparking face of an earthed electrode *B* is of constant section throughout. The axial length of the outer end face of each earthed electrode is small in comparison with the breadth of the end face in a direction normal to the axial direction.—*June* 9, 1954.

Technical Reports

Heavy Duty Contactor Contacts. Present Knowledge and Need for Research (Ref. G/T 287). By A. W. Baxter, B.Sc., M.I.E.E. The British Electrical and Allied Industries Research Association, Dorking Road, Leatherhead, Surrey. Price 10s. 6d., postage 3d.—The present position is reviewed and it is concluded that comparatively little is known about heavy-duty contacts. The fundamental theory underlying contact wear is not yet fully established and there is a need for basic data on which sound design can be based. The E.R.A. is therefore equipping a special laboratory where continuous three-phase power up to 600A at 440V, and much larger short-period powers, are available.

Aerodynamic Stability of Suspension Bridges. Bulletin No. 216. *Part IV.* University of Washington Engineering Experiment Station. By F. B. Farquharson.—The series of reports of which the present one is the fourth, cover various aspects of the well-known American researches on this subject. Part IV is entitled "Model Investigations which Influenced the Design of the New Tacoma Narrows Bridge" (Part V, the final part, will deal with investigations of more general application). A detailed description of the sectional and full models of various designs for the Tacoma Bridge, and of the tests carried out with them, is given in the report. Field observations and sectional model tests relating to the Golden Gate Bridge are also described.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

OPEN-ENDED SPANNERS

No. 192 : 1954. Price 5s. The latest revision of this standard for open-ended spanners deals with the steel from which the spanners should be manufactured and its treatment, proportions and dimensions. Since the standard was last revised in 1943, the range of hexagon sizes has been considerably extended by the addition of the several Unified series, and the tables have also been extended to cover these additions.

In this revision an attempt has been made to solve the difficult question of what special marking should apply to the spanners suitable for the new Unified hexagons. In the solution adopted the fractions are replaced by simple figures based on the decimal equivalent of the size across the flats.

FLANGED STEEL OUTSIDE-SCREW-AND-YOKE WEDGE GATE VALVES FOR THE PETROLEUM INDUSTRY

No. 1414 : 1954. Price 10s. The 1949 edition of this British Standard described materials specified by reference to specifications of the American Society of Testing Materials. Since then, British Standards equivalent to the A.S.T.M. specifications for steels have been published (B.S. 1501-6, "Steels for Use in the Chemical, Petroleum and Allied Industries") and are referred to in this revised edition. It is the intention that valves complying with this standard shall also meet the requirements of the latest edition of A.P.I. Standard 600, issued by the American Petroleum Institute, so as to ensure interchangeability, as units, between valves made in accordance with either of these standards. This British Standard specifies the ratings, design, materials, dimensions, tests and working for cast or forged steel rising-stem, outside-screw-and-yoke solid wedge gate valves with integral flanges, of Classes 150, 300, 400, 600, 900, 1500 and 2500 and of nominal sizes 1in to 24in.

CADMIUM-PLATED CLOSE TOLERANCE SHEAR PINS FOR AIRCRAFT

No. SP. 113 : 1954. Price 3s. This British Standard specifies the materials, dimensions, finish and part numbers of the shear pins, which are cadmium-plated to be suitable for insertion in aluminium alloy material. The standard is divided into three sections, the first specifying the requirements applicable to all pins, and the others dealing with the particular requirements for pins machined from bar and those produced by a cold heading process.

CADMIUM-PLATED STEEL BOLTS FOR AIRCRAFT

The following standards have been prepared to provide ranges of steel close tolerance bolts and shear bolts, cadmium-plated, to be suitable for insertion in aluminium alloy materials. No. A.59 : 1954. Price 3s. "Cadmium-Plated Hexagonal-Headed Steel Bolts (B.A. and B.S.F. Threads and Close Tolerance Shanks) for Aircraft." No. A.60 : 1954. Price 2s. "Cadmium-Plated Shear Bolts (B.S.F. Threads) for Aircraft." No. A.111 : 1954. Price 3s. "Cadmium-Plated Steel Bolts (Unified Hexagons, UNF. Threads and Close Tolerance Shanks) for Aircraft."

Launches and Trial Trips

DIADEMA XVII, tug; built by Brooke Marine, Ltd., for Diadema Argentina S.A. de Petroleo; length overall 48ft 8in, length between perpendiculars 44ft, breadth moulded 12ft 4in, depth moulded 5ft, draughts 2ft 9in forward, 4ft 6in aft; free running speed 8·87 knots, bollard pull 29 cwts at engine speed of 1350 r.p.m., turning circle two lengths; Thornycroft RZ/6 diesel engine, 105 b.h.p. at 1500 r.p.m., 3 to 1 reduction gear. Trial May 27th.

PRESIDENT BRAND, oil tanker; built by the Furness Shipbuilding Company, Ltd., for the Northern Steamships, Ltd., Johannesburg; length between perpendiculars 560ft, breadth moulded 80ft, depth moulded 42ft 3in, draught summer freeboard 32ft 3¼in, deadweight 24,575 tons, trial speed 14 knots; twenty-seven cargo oil tanks, two cargo pump rooms, four 500 tons per hour steam pumps, two 150 tons per hour stripping pumps; two 75kW steam-driven generators, one 35kW diesel-driven generator; N.E.M.-Doxford, single-acting, two-stroke oil engine, six cylinders 670mm diameter by 2320mm combined stroke, 6800 b.h.p. at 119 r.p.m., two Scotch boilers. Launch June 17th.

HADRA, oil tanker; built by Smith's Dock Company, Ltd., for Shell Tankers, Ltd.; length between perpendiculars 530ft, breadth moulded 69ft 3in, depth moulded 39ft, deadweight 18,000 tons on 29ft 6in draught, service speed 14·5 knots; thirty-three cargo oil tanks, one cargo pump room, four 400 tons per hour turbine-driven cargo pumps, two stripping pumps, steam deck machinery; two 550kW turbine-driven alternators, one 200kW diesel-driven alternator; machinery by R. and W. Hawthorn, Leslie and Co., Ltd., two-casing double reduction geared turbine taking steam at 500 lb per square inch and 800 deg. Fah. from two Foster Wheeler marine "D" boilers.

Contracts

FIBREGLASS, Ltd., has received an order to supply the anti-corrosion pipe wrap for the 350 mile long 16in diameter gas pipeline, to be laid by the Government of Pakistan, to supply Karachi with natural gas from Sui.

VICKERS-ARMSTRONGS, Ltd., has received from Butler Air Transport, Ltd., Australia, an order for two "Viscount" propeller turbined airliners. It brings to 101 the number of machines now on order.

Catalogues

MAIDEN AND CO., Ltd., Hyde, Cheshire.—Leaflet describing the "PR" bolt threading machine.

THE RENOLD AND COVENTRY CHAIN COMPANY, Ltd., Manchester.—Pamphlet dealing with steel chains for conveyors and elevators.

KODAK, Ltd., Medical Sales Division, Kodak House, Kingsway, London, W.C.2.—Booklet listing accessories for the X-ray dark room.

STEELE AND COWLISHAW, Ltd., Cooper Street, Hanley, Stoke-on-Trent.—Catalogue covering the "Steel-Shaw" range of ball and pebble mills.

RADFORD ELECTRONICS, Ltd., 149, Newfoundland Road, Bristol, 2.—Brochure describing a range of transformers for the electronics industry.

CROYDON PRECISION INSTRUMENT COMPANY, Ltd., 116, Windmill Road, Croydon, Surrey.—Leaflet No. 54 describing the type "P3" D.C. potentiometer.

MUREX WELDING PROCESSES, Ltd., Waltham Cross, Herts.—Leaflet No. E458, dealing with "Fortrex 35" electrodes for the metallic arc welding of medium and high-tensile steels.

AUTOMATIC TELEPHONE AND ELECTRIC COMPANY, Ltd., Strowger House, Arundel Street, London, W.C.2. Illustrated folders dealing with subscriber-attended private automatic branch exchanges.

HILGER AND WATTS, Ltd., Hilger Division, 98, St. Pancras Way, Camden Road, London, N.W.1.—Catalogues giving details of monochromators, spectrometers, refractometers, polarimeters, temperature regulators, strainviewers, photoelastic apparatus, electrophoresis apparatus, also illustrated catalogue of the Hilger recording infra-red spectrophotometer.

AIR CONTROL INSTALLATIONS, Ltd., Ruislip, Middlesex.—Illustrated folders: No. B522, "Cycoil" oil bath air cleaner. No. B521, "Airmat" dust arrester. No. B531, "Electro-PL" air filter. No. B543, "PL-24" air filter. No. B515, multi-duty automatic self-cleaning viscous air filter. No. B544, "LFO" viscous film type air filter. No. K491/R, unit air conditioners, type KD. No. FB532, small cast blowers. No. FA534, "Windovent" window fan. No. R533, Rotoclones for dust control.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME and PLACE at which the meeting is to be held should be clearly stated.

ASLIB

Fri. to Mon., Sept. 24th to 27th.—Church House, Westminster, London, S.W.1, 29th Annual Conference.